FINAL REPORT
PROJECT A-2442-001

A WOOD ENERGY DEMONSTRATION CENTER IN ALABAMA
PHASE I: A BACKGROUND INVESTIGATION

Prepared for

Office of Minority Business Enterprise
The United States Department of Commerce

By

Tze I. Chiang, Project Director
Edwin A. Bethea, Project Liaison
Meredith Richardson, Project Consultant

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GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station
Economic Development Laboratory
Atlanta, Georgia 30332
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Summary

A Phase I investigation concerning a wood energy demonstration center in a 50 mile radius of Troy, Alabama, was conducted to gather background data on timber resources, woodworking industries, wood residues, and potential uses of wood energy. The main purpose of Phase I was to obtain the necessary background information to provide a clear direction as to how this center should be organized. The study area included 13 counties in the southeast corner of Alabama.

Some 3,412,300 acres or 58% of the total land surface in the study area were classified as commercial timberland in 1972. Softwood species and hardwood species each occupy roughly one half of the commercial timberland. Pines (softwood) and oaks (hardwood) are the predominant species. Commercial timberland ownership is divided roughly among the following categories: farmer and miscellaneous private, 78%; forest industry, 18%; and publicly owned, 4%. In 1975, this area had 3,256.2 million cubic feet of growing stock, of which softwood constituted 57% and hardwood 43%. In this same year, sawtimber volume was 10,514.2 million board feet, of which 69% was softwood and 31% hardwood.

In 1974, the annual growth in growing stock in the area exceeded removal by 8.1 million cubic feet for softwood and by 6.6 million cubic feet for hardwood. In sawtimber, softwood growth exceeded removal by 25.8 million board feet and hardwood growth exceeded removal by 17.1 million board feet in the same year.

In recent years, the number of seedlings planted annually in the study area has varied from 70,000,000 to 100,000,000 and over. About 98% to 99% of the seedlings planted are pines, with loblolly pine alone accounting for 50%

to 85% of the seedlings planted. Thinning operations are carried out after 15 years for pulpwood, and sawtimber harvests can be carried out in 40 years. These thinning and harvesting operations are conducted continuously every year.

There were 80 primary woodworking concerns in the area in 1979, with sawmills and pulpwood production operations being the vast majority. Millwork, cabinet shops, and fixtures constituted the bulk of 42 secondary woodworking concerns located in the area in the same year. In 1977, the area produced 1,118,348 standard cords of pulpwood, of which 74% was softwood and 76% hardwood. Lumber production in that year was 216.7 million board feet, comprising 79% softwood and 21% hardwood. Pulpwood chips production increased from 166 thousand cords in 1968 to 305 thousand cords by 1977, an increase of 84% in 10 years.

The potential sources of wood fuel supplies are mill residues, forest residues, and whole-tree chipping. There were 55,000 tons of unused and uncommitted mill residues reported in 1979 and 110,000 tons estimated. This volume is only about 5% of the total mill residues generated yearly in the area. Forest residues, with 1,188,000 tons estimated annually, are the largest potential supplies of wood fuel in the area. This source has not yet been tapped for utilization. Whole-tree chipping is a new technology. On a sustained yield basis, the area can afford to produce 175,000 tons of whole-tree chips a year.

In November 1979, a survey on energy-use patterns was conducted in the area. The results reveal that natural gas and electricity are the two most important sources of energy used in the area. Trailing far behind are oil, propane, and wood. The types of energy equipment most frequently used are

heaters, ranges, furnaces, dryers, boilers, and stoves. Average fuel costs in November 1979, on a per million-Btu basis were $12.76 for electricity, $5.65 for propane, $5.04 for oil, $3.53 for natural gas, and $1.06 for wood.

About 68% of the residential respondents expressed interest in wood as a potential fuel source as did 36% of the manufacturing respondents, 10% of the commercial respondents, and none of the institutional respondents. About 72% of the survey respondents indicated that potential wood-fuel supplies are located nearby, with an average distance of 4 miles to 11 miles. Sawmills are the main source of supply.

A review of major wood-fuel technologies was conducted. Included were wood-fired package boilers, suspension and cyclone burners, fluidized bed combustors, pyrolysis systems, wood gasifiers, and electric power generation. Characteristics of each technology, system availability, fuel moisture content, and unit capacity are outlined in the report. A final choice of electrical power generation as a means to organize a wood energy demonstration center in Alabama is recommended. The choice is based on six considerations. First, electricity is a widely used energy source and the most expensive form of energy in the study area. Second, federal and state governments have provided legislative and tax incentives by law to small electrical power producers in using biomass fuel sources. Third, the technology for small electrical power plants is available on a commercial basis. Fourth, interest in locally generated electrical power has been expressed. Fifth, wood fuel supplies for a small power plant can be arranged in the area. Sixth, the center should be financially self-supporting once the power plant is established.

INTRODUCTION

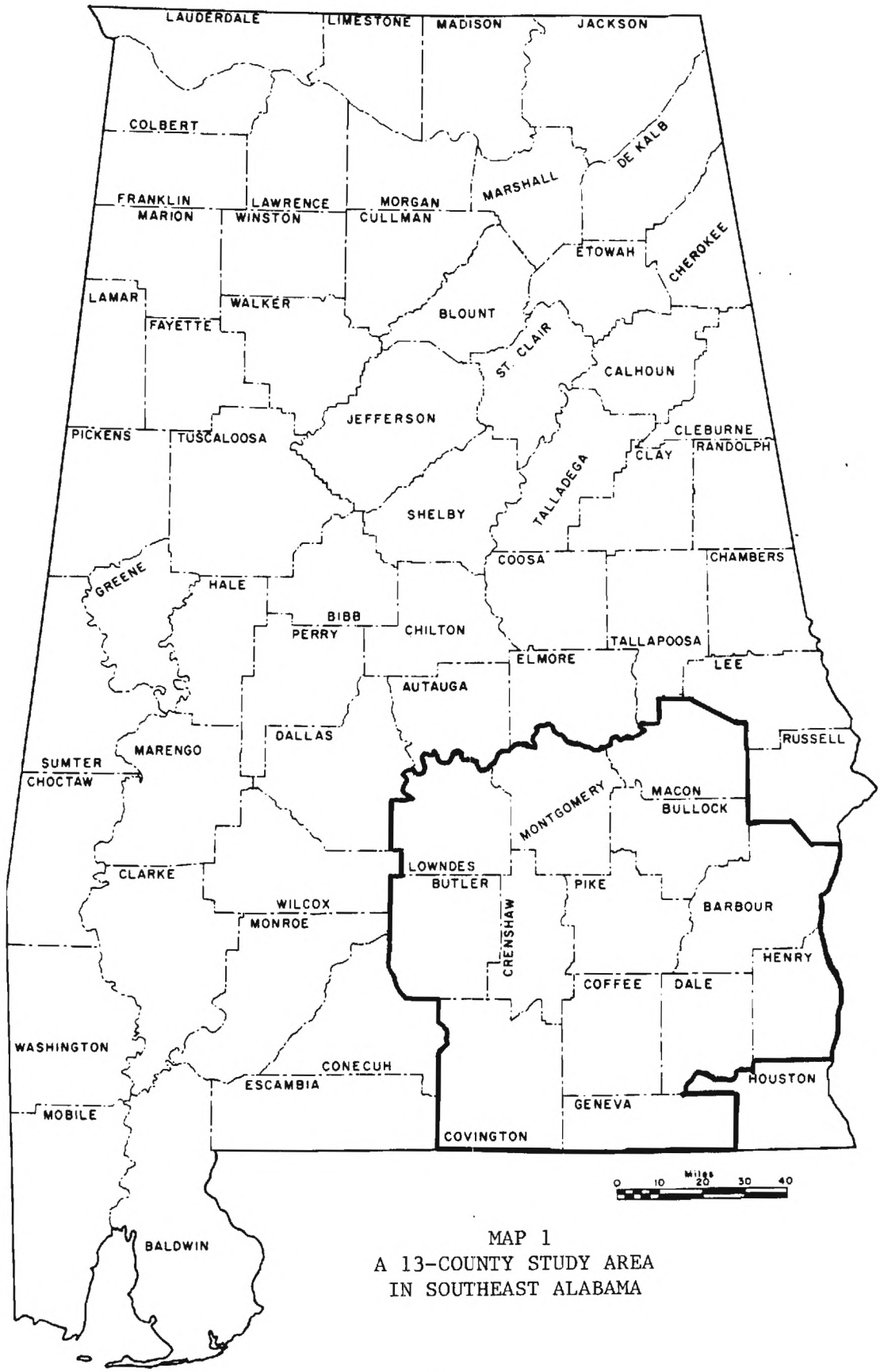
In 1979, the United States Department of Commerce, Office of Minority Business Enterprise, provided a six-month study grant to the Economic Development Laboratory, Engineering Experiment Station, through the Georgia Tech Research Institute, for the purpose of conducting Phase I of an investigation concerning a wood energy demonstration center to be located in Alabama.

The main objective of Phase I was to gather background data needed for organizing the wood energy demonstration center. Four main areas have been investigated under Phase I: timber resources, woodworking industries, wood residues, and potential uses of wood energy generated.

The study area is a 50-mile radius of Troy, Alabama. For the convenience of conducting the investigation, 13 Alabamas counties were included in the study: Barbour, Bullock, Butler, Coffee, Covington, Crenshaw, Dale, Geneva, Henry, Lowndes, Macon, Montgomery, and Pike. These 13 Alabama counties are located in the southeastern corner of the state. (See Map 1.)

The results of the Phase I investigation are organized into five parts. Part one provides a review of the timber resources in the 13-county area, including commercial forest area, timberland ownership, timber inventories, timber growth and removal, and seedling planting trends. Part two identifies woodworking concerns in the area and main wood products produced. Part three gives the potential wood fuel supplies including the results of a wood residues survey and estimated volume of annual forest residues and allowable whole-tree chipping. Part four provides the results of an energy-use survey in the area. The tabulated results include fuel type and equipment, fuel costs, wood as a potential source of fuel, and comments. Part five illustrates major wood-fuel technologies such as boilers, burners, fluidized bed combustors, pyrolysis systems, wood gasifiers, and electric power generation.

The Phase I investigation has provided the necessary data and background information to evaluate the possibility of establishing a wood energy demonstration center and to determine the direction it should take. A PhaseII investigation would be required in order to finalize the programs and organization of the proposed center.



MAP 1
A 13-COUNTY STUDY AREA
IN SOUTHEAST ALABAMA

COMMERCIAL FOREST LAND AND TIMBER RESOURCES

Commercial Forest Area

Some 3,412,300 acres, or 58% of the 5,834,200 acres of total land surface in the 13-county study area, were classified as commercial timberland in 1972. Detailed statistics on the total land area and commercial forest land in 1972 in each county in the study area vs. Alabama totals are given in Table 1. About 65% of Alabama's total land area was classified as commercial forest land. The 13-county area constituted 17.66% of Alabama's land area and contained 16% of the commercial forest land in the state in 1972. Both the 13-county area and the state of Alabama lost 2% of their commercial forest land between 1963 and 1972.

Of the 3,412,300 acres of commercial forest land in the 13-county area, approximately 8% is in longleaf-slash pine, 28% in loblolly-shortleaf pine, 20% in oak-pine, 26% in oak-hickory, 17% in oak-gum-cypress, and 1% in elm-ash-cottonwood. Softwood species and hardwood species each occupy roughly one half of the commercial forest land in the area, with pines (softwood) and oaks (hardwood) predominating. Detailed statistics by county are presented in Table 2.

Areas classified as commercial timberland vary widely in timber-producing potential, but all are judged capable of growing at least 20 cubic feet of timber per year and are suitable, either now or prospectively, for timber harvesting. In the study area, about 47% of commercial forest land is in the 85-120 cu. ft. category, 34% in the 50-85 cu. ft. bracket, 14% in the 120-165 cu. ft. class, 3% in the range 165 cu. ft. or more, and 2% in the less than 50 cu. ft. class. Details are given in Table 3.

Ownership of Commercial Timberland

In 1972, about 4% of the commercial forest land in the study area was under public ownership such as national forest and state- or county-owned land. The forest industry owned about 18%, and farmer and miscellaneous private ownerships constituted about 78%. Miscellaneous private owners comprise business and professional people, wage and salary workers, housewives, and other nonfarm owners. County-by-county details are given in Table 4.

Table 1

TOTAL LAND AREA AND COMMERCIAL FOREST LAND
IN THE 13-COUNTY AREA AND ALABAMA, 1972

County	Total Area (1000 Acres)	Commercial Forest		
		Area (1000 ACRES)	Pro-Portion (%)	Change 1963-72 (%)
Barbour	575.4	385.0	67	+1
Bullock	393.6	232.2	59	+1)
Butler	494.7	371.2	75	(2)
Coffee	433.3	241.5	56	+2
Covington	662.4	450.0	68	+2
Crenshaw	391.0	274.5	70	+7
Dale	358.4	225.5	63	+9
Geneva	369.9	159.0	43	-10
Henry	361.6	209.1	58	(2)
Lowndes	460.2	224.0	49	-9
Macon	394.2	218.4	55	-8
Montgomery	508.8	171.1	34	-17
Pike	430.7	250.8	58	+4
Area Total	5,834.2	3,412.3	58	-2
Alabama Total	33,029.8	21,333.1	65	-2

* Negligible

Source: Arnold Hedlund and J. M. Earles, Forest Statistics for Alabama Counties, Forest Service Resource Bulletin SO-39, Southern Forest Experiment Station, New Orleans, Louisiana, 1973.

Table 2

COMMERCIAL FOREST LAND BY FOREST TYPE IN THE 13-COUNTY AREA AND IN ALABAMA, 1972

(in thousands of acres)

County	All Types	Longleaf Slash Pine	Loblolly Shortleaf Pine	Oak Pine	Oak Hickory	Oak Gum Cypress	Elm-Ash-Cotton Wood
Barbour	385.0	22.0	170.5	66.0	88.0	38.5	-
Bullock	232.2	-	97.2	27.0	64.8	43.2	-
Butler	371.2	5.8	145.0	87.0	87.0	40.6	5.8
Coffee	241.5	13.8	48.3	62.1	82.8	34.5	-
Covington	450.0	144.0	72.0	84.0	102.0	48.0	-
Crenshaw	274.5	18.3	54.9	79.3	48.8	73.2	-
Dale	225.5	5.5	66.0	44.0	88.0	22.0	-
Geneva	159.0	37.1	-	15.9	53.0	53.0	-
Henry	209.1	5.1	81.6	45.9	56.1	20.4	-
Lowndes	224.0	-	61.6	50.4	61.6	44.8	5.6
Macon	218.4	-	57.2	57.2	52.0	52.0	-
Montgomery	171.0	-	47.2	23.6	41.3	59.0	-
Pike	250.8	22.8	62.7	51.3	62.7	51.3	-
Area Total	3,412.3	274.4	964.2	693.7	888.1	580.5	11.4
Alabama Total	21,333.1	1,483.6	6,380.1	5,016.9	5,913.1	2,443.5	95.9

Source: Arnold Hedlund and J. M. Earles, op. cit.

Table 3

COMMERCIAL FOREST LAND BY SITE CLASS IN THE 13-COUNTY AREA AND IN ALABAMA, 1972

(in thousands of acres)

County	All Classes	165 Cu. Ft. or More	120-165 Cu. Ft.	85-120 Cu. Ft.	50-85 Cu. Ft.	Less Than 50 Cu.Ft.
Barbour	385.0	5.5	110.0	187.0	82.5	-
Bullock	232.2	10.8	27.0	108.0	86.4	-
Butler	371.2	-	81.2	156.6	127.6	5.8
Coffee	241.5	6.9	27.6	131.1	69.0	6.9
Covington	450.0	30.0	102.0	162.0	150.0	6.0
Crenshaw	274.5	-	12.2	115.9	140.3	6.1
Dale	225.5	5.5	22.0	66.0	121.0	11.0
Geneva	159.0	-	5.3	68.9	68.9	15.9
Henry	209.1	5.1	20.4	132.6	45.9	5.1
Lowndes	224.0	22.4	22.4	140.0	39.2	-
Macon	218.4	10.4	26.0	72.8	109.2	-
Montgomery	171.1	-	17.7	106.2	41.3	5.9
Pike	250.8	-	-	165.3	79.8	5.7
Area Total	3,412.3	96.6	473.8	1,612.4	1,161.1	68.4
Alabama Total	21,333.1	413.4	2,334.2	7,947.7	9,175.6	1,462.2

Source: Arnold Hedlund and J. M. Earles, op. cit.

Table 4

COMMERCIAL FOREST LAND BY OWNERSHIP CLASS IN THE 13-COUNTY AREA AND IN ALABAMA, 1972

(in thousands of acres)

County	All Ownerships	National Forest	Other Public	Forest Industry	Farmer	Misc. Private
Barbour	385.0	-	15.8	60.5	109.9	198.8
Bullock	232.2	-	10.8	10.8	64.8	156.6
Butler	371.2	-	0.3	150.8	121.7	98.4
Coffee	241.4	-	10.2	41.4	117.2	72.7
Covington	450.0	54.2	2.1	156.0	158.5	79.2
Crenshaw	274.5	-	0.2	42.7	115.8	115.8
Dale	225.5	-	33.8	-	87.9	103.8
Geneva	159.0	-	7.2	5.3	79.5	67.0
Henry	209.1	-	0.9	30.6	81.5	96.1
Lowndes	224.0	-	1.5	50.4	89.5	82.6
Macon	218.4	9.8	1.5	31.2	98.7	77.2
Montgomery	171.1	-	1.3	-	100.2	69.6
Pike	250.8	-	0.4	22.8	159.5	68.1
Area Total	3,412.3	64.0	75.2	602.5	1,384.7	1,285.9
Alabama Total	21,333.1	629.5	391.0	4,204.9	6,732.5	9,375.2

Source: Arnold Hedlund and J. M. Earles, op. cit.

Timber Inventories

Most timber harvests must come from trees now standing on commercial timberlands. The volume, species, tree diameter, location, quality, and ownership of this standing timber are of major importance in appraising the present and future timber situation in the study area. Timber inventories are analyzed in terms of growing stock and sawtimber in the following two sections.

Growing Stock. "Growing stock" refers to trees with 5.0 inches d.b.h.[1/] and over from a one-foot stump to a minimum 4.0 inches top diameter outside bark of the central stem, or to the point where the central stem breaks into limbs. Growing-stock volume is net volume in cubic feet of growing-stock trees, which are the sources for pulpwood and lumber

A comparison of growing stock volume on commercial forest land in 1963 and 1975 in the study area is given in Table 5. The growing stock volume, all species, increased from 2,246 million cubic feet in 1963 to 3,256.2 million cubic feet in 1975, a 45% gain in 12 years or an annual rate of 3.1%. Among the 13 counties in the area, only one registered a decline; the rest of the counties had gains in growing stock volume ranging from 5% to 86%.

Softwood growing stock volume, which constitutes slightly more than half of the total growing stock volume in the area, rose from 1,239.1 million cubic feet in 1963 to 1,852.6 million cubic feet in 1975, a 49.5% increase at a 3.4% annual rate. The change in softwood growing stock volume in the 12-year period varied greatly among individual counties. Two counties registered a loss and one had no significant change; the rest experienced volume gains ranging from 39.7% to 163.9%.

Hardwood growing stock volume increased from 1,006.9 million cubic feet in 1963 to 1,403.6 million cubic feet in 1975, a 39.4% increase at an annual rate of 2.8%. Naturally, the growth rate of hardwood is somewhat slower than softwood. Eleven counties registered a gain during the 12-year period ranging from 3% to 87.9%.

[1/] Diameter at breast height.

Table 5

COMPARISON OF GROWING STOCK VOLUME ON COMMERCIAL FOREST LAND
IN THE STUDY AREA, 1963 and 1975
(in million cubic feet)

	All Species			Softwood			Hardwood		
	1963	1975	% Change	1963	1975	% Change	1963	1975	% Change
Barbour	229.4	426.9	86.1	151.1	279.8	85.2	78.3	147.1	87.9
Bullock	127.7	212.2	66.2	85.2	136.9	60.7	42.5	75.3	77.2
Butler	283.7	379.3	33.7	185.7	237.8	28.1	98.0	141.5	44.4
Coffee	88.4	162.6	83.9	36.8	97.1	163.9	51.6	65.5	26.9
Covington	303.6	426.6	40.5	216.1	301.8	39.7	87.5	124.8	42.6
Crenshaw	256.9	268.9	4.7	132.1	131.9	0	124.8	137.0	9.8
Dale	141.6	213.6	50.8	63.5	99.6	56.8	78.1	114.0	46.0
Geneva	111.7	108.3	-3.1	41.0	35.5	-15.5	70.7	72.8	3.0
Henry	108.0	198.6	83.9	60.4	134.7	123.0	47.6	63.9	34.2
Lowndes	224.3	243.2	8.4	116.8	106.7	-9.5	107.5	136.5	27.0
Macon	133.0	211.0	58.6	65.4	98.0	50.0	67.6	113.0	67.2
Montgomery	93.3	171.6	83.9	34.0	75.8	122.9	59.3	95.8	61.5
Pike	144.4	233.4	61.6	51.0	117.0	129.4	93.4	116.4	24.6
Area Total	2,246.0	3,256.2	45.0	1,239.1	1,852.6	49.5	1,006.9	1,403.6	39.4
Alabama Total	14,447.9	21,360.6	47.8	7,673.1	11,913.9	55.3	6,774.8	9,446.7	39.4

Sources: Herbert S. Sternitzke, Albama Forests, U.S.D.A., Forest Service, Southern Forest Experiment Station, New Orleans, Louisiana, 1963.

Roy C. Beltz, Alabama's Timber Resources Updated, 1975, Forest Service Resource Bulletin SO-55, U.S.D.A., Southern Forest Experiment Station, New Orleans, Louisiana, 1975.

Sawtimber. Sawtimber trees are live trees of commercial species containing at least a 12-foot saw log or two noncontiguous saw logs, each eight feet or longer, and with at least one third of the gross board-foot volume between the one-foot stump and minimum saw log being sound. Softwoods must be at least 9.0 inches and hardwoods at least 11.0 inches in diameter at breast height. Sawtimber volume is measured in net volume of the saw log portion of live sawtimber in board-foot international 1/4-inch rule.

A comparison of sawtimber volume on commercial forest land in 1963 and 1975 in the study area is given in Table 6. The total sawtimber volume grew from 7,447.7 million board-feet to 10,514.2 million board-feet, a 41.8% increase in 12 years or an annual rate of 3%. Only two counties in the area registered a loss of sawtimber volume, while the remainder had gains ranging from 14.4% to 104.2%.

Softwoods constitute nearly 60% of the total sawtimber volume. The volume rose from 4,911.3 million board feet in 1963 to 7,289.1 million board-feet in 1975, an increase of 48.4% during the period or an annual rate of 3.3%.

Hardwood sawtimber volume increased from 2,503.4 million board-feet to 3,225.1 million board-feet during the 12-year period. This represents a total increase of 28.8% and an annual rate of 2.1%. The rate of gain in hardwood sawtimber volume is lower than that for softwoods in the study area.

Timber Growth and Removal

Comparison of figures on timber growth and removal reveals whether there has been a net gain or loss in the timber base in a given area. Continued excess of growth over removal results in increased timber volume; conversely, when growth is consistently smaller in volume than removal, the result is a diminished timber base. Alabama has enjoyed sustained net gains in timber volume of both softwood and hardwood. In the 13-county study area, however, timber growth is barely ahead of timber removal. The average growth per acre in the 13-county area was 57 cubic feet in 1974, compared with 60 cubic feet in Alabama and 45 cubic feet in the South as a whole.

Table 6

COMPARISON OF SAWTIMBER VOLUME ON COMMERCIAL FOREST LAND
IN THE STUDY AREA, 1963 and 1975
(in million board feet)

	All Species			Softwood			Haredwood		
County	1963	1975	% Change	1963	1975	% Change	1963	1975	% Change
Barbour	784.0	1336.5	70.5	599.6	1030.8	71.9	184.4	305.7	65.8
Bullock	430.1	674.9	56.9	327.5	508.0	55.1	102.6	166.9	62.7
Butler	1052.0	1464.5	39.2	773.2	1061.3	37.3	278.8	403.2	44.6
Coffee	216.5	442.1	104.2	121.8	289.2	37.4	94.7	152.9	61.5
Covington	1008.1	1466.0	45.4	859.3	1259.6	46.6	148.8	206.4	38.7
Crenshaw	824.9	944.1	14.4	512.6	603.9	17.8	312.3	340.2	8.9
Dale	401.7	657.4	63.6	211.6	399.2	88.7	190.1	258.2	35.8
Geneva	361.1	254.2	-42.1	162.4	121.0	-34.2	198.7	133.2	-49.2
Henry	324.9	540.7	66.4	216.5	431.6	99.3	108.4	109.1	1.0
Lowndes	877.7	859.9	-2.1	559.1	472.4	-18.3	318.6	387.5	21.6
Macon	411.3	640.9	55.8	253.8	395.4	55.8	157.5	245.5	55.9
Montgomery	267.1	472.1	76.7	122.2	267.9	19.2	144.9	204.2	40.9
Pike	455.3	760.9	67.1	191.7	448.8	34.1	263.6	312.1	18.4
Area Total	7,414.7	10,514.2	41.8	4,911.3	7,289.1	48.4	2,503.4	3,225.1	28.8
Alabama Total	46,601.9	66,821.3	43.4	28,306.7	44,390.8	56.8	18,295.2	22,430.5	22.6

Sources: Herbert S. Sternitzke, Alabama Forests, U.S.D.A., Forest Service, Southern Forest Experiment Station, New Orleans, Louisiana, 1963

Roy C. Beltz, Alabama's Timber Resources Updated, 1975, Forest Service Resource Bulletin SO-55, U.S.D.A., Southern Forest Experiment Station, New Orleans, Louisiana, 1975

Growing Stock. Annual growth, removal, and net change in softwood and hardwood growing stock in the 13-county area and in Alabama is presented in Table 7. Annual growth in softwood growing stock in the study area amounted to 130.2 million cubic feet and removals totaled 122.1 million cubic feet, yielding a net gain of 8.1 million cubic feet in 1974. The cut-to-growth ratio of softwood growing stock was 94% in the 13-county area and 72% in Alabama.

Data on hardwood growing stock in terms of annual growth, removal, and net change in 1974 are given in the same table. The 13-county area had a net growth of 65.6 million cubic feet and removal of 59 million cubic feet, resulting in a net gain of 6.6 million cubic feet. The corresponding figures for Alabama were 432.5 million cubic feet, 254.9 million cubic feet, and 177.6 million cubic feet. The cut-to-growth ratio of hardwood growing stock was 90% in the 13-county area and 59% in Alabama.

In the 13-county area, total net growth of growing stock (softwood and hardwood) amounted to 195.8 million cubic feet and total removals were 181.1 million cubic feet in 1974. The cut-to-growth ratio was 92% compared with 68% in Alabama. From the point of view of sustained yield, timber resources in the study area have been used up to the limit in recent years.

Sawtimber. Data on net annual growth, timber removal, and net change for softwood and hardwood sawtimber on commercial forest land in 1974 are presented in Table 8. The 13-county area experienced growth of 505.9 million board-feet, removal of 480.1 million board-feet, and a net gain of 25.8 million board-feet in softwood sawtimber. Removals amounted to 95% of the growth in the study area compared with 73% in Alabama as a whole.

For hardwood sawtimber, the growth was 150.4 million board-feet and removals totaled 133.3 million board-feet, yielding a net gain of 17.1 million board-feet in the study area in 1974. The cut-to-growth ratio was 89% in the area compared with 58% in Alabama.

Statistics for all sawtimber (softwood and hardwood) in the study area in 1974 were a net growth of 656.3 million board-feet, removal of 613.4 million board-feet, and a net gain of 42.9 million board-feet. Removals amounted to 93% of the growth in the 13-county area vs. 69% in Alabama as a whole.

Table 7

NET ANNUAL GROWTH, TIMBER REMOVAL, AND NET ANNUAL CHANGE FOR SOFTWOOD AND HARDWOOD GROWING STOCK ON COMMERCIAL FOREST LAND IN THE 13-COUNTY AREA AND IN ALABAMA, 1974
(in millions of cubic feet)

	Softwood			Hardwood		
County	Annual Growth	Annual Removal	Net Change	Annual Growth	Annual Removal	Net Change
Barbour	20.1	10.1	10.0	7.2	3.3	3.9
Bullock	10.9	12.5	-1.6	4.3	3.2	1.1
Butler	14.8	14.4	0.4	5.8	4.6	1.2
Coffee	8.2	6.1	2.1	3.1	3.6	-0.5
Covington	17.3	18.4	-1.1	5.4	4.9	0.5
Crenshaw	8.1	10.6	-2.5	5.1	6.2	-1.1
Dale	8.0	8.4	-0.4	5.4	4.8	0.6
Geneva	2.5	5.8	-3.3	3.4	1.5	1.9
Henry	11.5	9.3	2.2	3.3	7.2	-3.9
Lowndes	7.5	6.5	1.0	6.0	2.0	4.0
Macon	7.7	5.8	1.9	4.9	5.0	-0.1
Montgomery	5.3	4.4	0.9	5.5	3.2	2.3
Pike	8.4	9.8	-1.4	6.2	9.5	-3.3
Area Total	130.2	122.1	8.1	65.6	59.0	6.6
Alabama Total	838.0	599.8	238.2	432.5	254.9	177.6

Sources: Roy C. Beltz, Alabama's Timber Resources Updated, 1975, Forest Service Resource Bulletin SO-55, Southern Forest Experiment Station, New Orleans, Louisiana, 1975.

Table 8

NET ANNUAL GROWTH, TIMBER REMOVAL, AND NET ANNUAL CHANGE FOR SOFTWOOD AND HARDWOOD GROWING STOCK ON COMMERCIAL FOREST LAND IN THE 13-COUNTY AREA AND IN ALABAMA, 1974
(in millions of cubic feet)

	Softwood			Hardwood		
County	Annual Growth	Annual Removal	Net Change	Annual Growth	Annual Removal	Net Change
Barbour	73.9	37.0	36.9	14.9	6.8	8.1
Bullock	40.3	46.2	-5.9	9.5	7.0	2.5
Butler	65.9	64.3	1.6	16.6	13.1	3.5
Coffee	24.5	18.2	6.3	7.3	8.3	-1.0
Covington	72.2	76.9	-4.7	9.0	8.1	0.9
Crenshaw	37.3	48.5	-11.2	12.8	15.3	-2.5
Dale	31.9	33.8	-1.9	12.2	10.9	1.3
Geneva	8.6	19.8	-11.2	6.2	2.8	3.4
Henry	37.1	29.9	7.2	5.7	12.2	-6.5
Lowndes	32.5	28.8	3.7	17.0	5.5	11.5
Macon	30.9	23.5	7.4	10.7	10.9	-0.2
Montgomery	18.7	15.5	3.2	11.8	6.9	4.9
Pike	32.1	37.7	-5.6	16.7	25.5	-8.8
Area Total	505.9	480.1	25.8	150.4	133.3	17.1
Alabama Total	3,051.7	2,230.1	821.6	1,018.1	594.5	423.6

Source: Roy C. Beltz, op. cit.

Seedling Planting Trends

Timber resources in a given area and the productivity of timberland can be improved by seedling planting. In the 13-county area, the planting of seedlings has been carried out regularly over the last three to four decades. In the early 1950s, a few million seedlings were planted in the area each year. The number of trees planted in the area increased to about 50 million seedlings in 1959-60, a peak period, then declined to about 5 million in the mid-1960's, and gradually rising again to 16-18 million annually in recent years, aside from natural reforestation. (See Table 9.)

Seedlings have been planted on converted farmland or on hardwood stands after cutting. About 98% to 99% of the seedlings planted were pines, with loblolly pine alone constituting between 50% and 85% of the seedlings planted each year. Hardwood species such as yellow poplar, sycamore, sweetgum, and dogwood, constituted only 1% to 2%.

About 700 seedlings generally are planted per acre (spaced eight feet apart). In 15 years, pulpwood size is reached. The first thinning is carried out then, followed by another thinning every five years. In 40 years, one acre would contain 195 trees of sawtimber size, between 12 and 15 inches in diameter, or about 18,500 board-feet per acre. Continuation of seedling planting is a sure way to give the area greater timber resources in the years to come.

Alabama has an impressive seedling planting program, and the 13-county area compares well with the state. Table 9 shows the number of seedlings planted in the 13-county area and in Alabama since 1950. The number has fluctuated to some extent from one period to another. However, both the area and the state have followed the same trend: a peak at the late 1950s, a trough in the mid 1960s, and an uneven pattern in the 1970s. Figure 1 shows the pattern of seedlings planted in the 13-county area since 1950. Table 9 gives the percentage of the Alabama seedling planting total represented by the area for each year. The large number of trees planted in the area in the late 1950s will be ready for harvest either as pulpwood or as sawtimber in the next two decades.

TABLE 9

NUMBER OF SEEDLINGS PLANTED IN THE 13-COUNTY AREA AND ALABAMA, 1950 to 1978

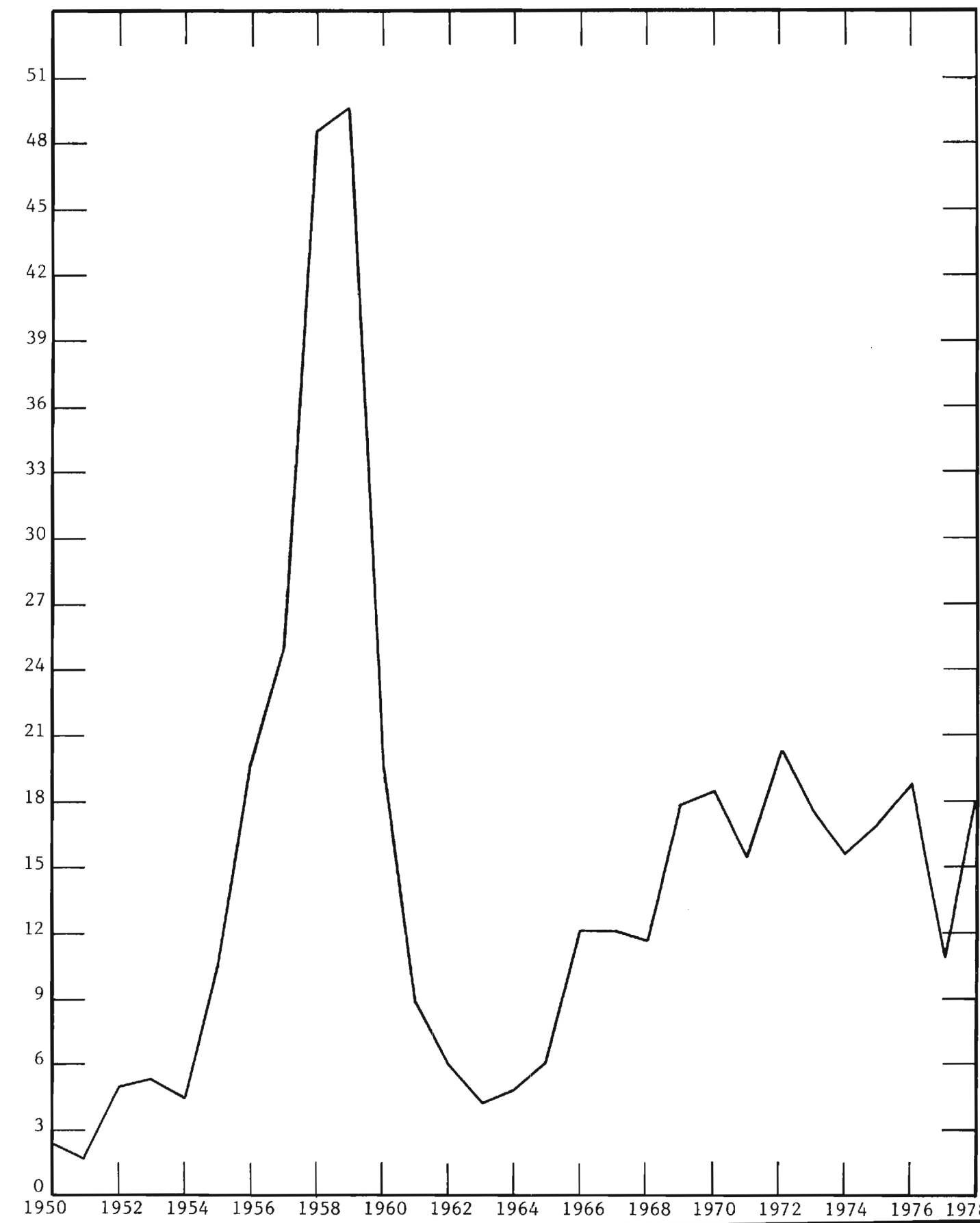
(in thousands of seedlings)

Year	13-County Area	Alabama	13 COUNTIES As a % of Alabama
1950-51	2,303.2	16,220.9	14.2
1951-52	1,841.4	16,353.1	11.3
1952-53	5,229.0	39,277.5	13.3
1953-54	5,411.3	33,980.5	15.9
1954-55	4,628.3	37,213.4	12.4
1955-56	10,372.4	49,906.8	20.8
1956-57	19,775.0	90,365.0	21.9
1957-58	25,016.3	122,327.7	20.4
1958-59	48,588.2	204,390.9	23.8
1959-60	49,668.3	177,420.7	28.0
1960-61	19,773.7	114,558.3	17.3
1961-62	8,861.5	73,635.6	12.0
1962-63	5,921.7	66,004.2	9.0
1963-64	4,337.6	58,716.9	7.4
1964-65	4,870.2	51,740.9	9.4
1965-66	6,120.6	56,256.5	10.9
1966-67	12,194.8	64,675.3	18.9
1967-68	12,133.5	72,406.4	16.8
1968-69	11,568.4	82,392.8	14.0
1969-70	17,722.6	91,374.8	19.4
1970-71	18,451.2	104,903.4	17.6
1971-72	15,540.6	88,300.5	17.6
1972-73	20,271.9	100,043.8	20.3
1973-74	17,563.6	81,487.2	21.6
1974-75	15,566.7	100,543.7	15.5
1975-76	16,982.1	80,770.4	21.0
1976-77	18,857.4	74,109.7	25.4
1977-78	10,820.8	91,654.1	11.8
1978-79	18,759.0	108,084.1	17.4

Source: Alabama Forestry Commission.

Figure 1

SEEDLINGS PLANTED IN THE 13-COUNTY AREA, 1950 to 1978



WOODWORKING CONCERNS AND TIMBER UTILIZATION

Woodworking Concerns in the Area

Timber utilization in a given area can be indicated by the type of wood-using concerns located in that area and major products produced. In the 13-county area, there are 80 primary wood-using concerns. They may be classified into seven major categories: pulp and paper, sawmills and planing mills, veneer and plywood, poles and pilings, pulpwood and wood chips, treating plants, and logging. Each concern is classified only under one major category even though it may involve several other categories. For example, a sawmill produces not only lumber, but also wood chips or other products; however, it is classified as a sawmill only.

The study area is heavily dominated by 32 sawmills and planing mills and 32 pulpwood and wood chip producers. (See Table 10.) The remaining 16 establishments are in the other five categories. Names, addresses, and other information on these 80 primary woodworking concerns in the area are given in Appendix 1.

Table 10

PRIMARY WOODWORKING CONCERNS IN THE 13-COUNTY STUDY AREA, ALABAMA, 1979

Kind	Number
Pulp and paper	1
Sawmills and planing mills	32
Veneer and plywood	6
Poles and pilings	2
Pulpwood and wood chips	32
Treating plants	3
Logging	4
Total	80

Source: 1979 Alabama Manufacturing Directory.

The 13-county area has 42 secondary woodworking concerns classified into six major categories: 26 millwork, cabinet or fixture shops; four furniture plants; one hardwood dimension plant, six housing-components producers, and five concerns producing miscellaneous products. (See Table 11.) Secondary woodworking plants generally purchase lumber or dimensional stocks from primary woodworking plants. Wood residues generated by both primary and secondary woodworking concerns are easily accessible sources of fuel material for energy purposes in the area. Names, addresses, and other information on the 42 secondary woodworking concerns are given in Appendix 2.

Table 11

SECONDARY WOODWORKING CONCERNS IN THE 13-COUNTY AREA, ALABAMA, 1979

Kind	Number
Millwork, cabinet and fixtures	26
Furniture	4
Hardwood dimension parts	1
Housing components	6
Others*	5
Total	42

* Mulches, strips, stakes, hubs, turkey calls, blinds, etc.

Source: 1979 Alabama Manufacturing Directory.

Round Pulpwood Production

Round pulpwood production in the 13-county area increased from 434,253 standard cords in 1957 to a peak of 1,313,918 standard cords in 1974 and then declined to 1,118,348 standard cords in 1977, for an annual gain rate of 4.8%. Pine pulpwood constituted the bulk of total pulpwood production in the area. Pine pulpwood rose from 420,288 standard cords in 1957 to a peak of 917,709 standard cords in 1974 and declined to 826,535 standard cords in 1977, for an annual increase rate of 3.4%. In contrast, hardwood pulpwood production grew from 13,965 standard cords in 1957 to a peak of 396,209

standard cords in 1974 and declined to 291,813 standard cords in 1977, representing a 16.4% average annual gain. Although the rate of production increase for hardwood pulpwood is much faster than that for pine pulpwood in the area, the hardwood percentage of total pulpwood production in the area has followed a declining trend after reaching a peak of 37% in 1969. The details of round pulpwood production in the area are given in Table 12 and are illustrated in graphic form in Figure 2.

Lumber Production

The production of lumber in the 13-county area has fluctuated from one year to another, typifying the lumber industry. However, pine lumber production in the area may have experienceda slight upward trend between 1962 and 1977, and hardwood lumber production appears to have followed a slight down trend in the same period. Between 1962 and 1977, pine lumber production fluctuated between 120 million board feet and 220 million board feet a year, while the hardwood lumber output jogged between 30 million board feet and 60 million board-feet annually. The hardwood percentage of total lumber production in the area has followed a clear downward trend. Data on lumber production in the area are presented in Table 13 and Figure 3.

Wood Chips Production

Wood chips production is an integral part of sawmill operation in most cases. A few pulpwood harvesters also produce wood chips. Between 1968 and 1977, wood chips production in the 13-county area increased from 66,000 cords to 304,900 cords at an annual rate of 7%. Although some fluctuations in production occurred during this period, the trend generally was upward. (See details in Table 14 and Figure 4.)

Wood chips can become an important source of wood energy in the area because of improved production technology in recent years and readily available noncommercial wood species in most of southern forests. Wood chips can be used directly in boilers designed for coal or bark fuels or in gasifiers.

Table 12

ROUND TABLE PULPWOOD PRODUCTION IN THE 13-COUNTY AREA,
1957 to 1977

(in standard cords)

Year	Pine	Hardwood	TOTAL	Hardwood As a % OF TOTAL
1957	420,288	13,965	434,253	3
1958	420,806	28,643	449,449	6
1959	412,484	104,553	517,037	20
1960	381,469	94,463	475,932	20
1961	396,497	108,559	505,056	21
1962	356,027	118,890	474,917	25
1963	400,613	92,072	492,685	19
1964	532,297	159,845	692,142	23
1965	634,444	216,235	850,679	25
1966	698,758	271,467	970,225	28
1967	808,055	267,564	1,075,619	25
1968	641,089	364,050	1,005,139	36
1969	670,404	391,427	1,061,831	37
1970	777,088	343,853	1,120,941	31
1971	692,601	289,483	982,084	29
1972	857,524	359,189	1,216,713	30
1973	884,050	359,146	1,243,196	29
1974	917,709	396,209	1.313,918	30
1975	791,778	243,290	1.035,068	24
1976	810,174	267,442	1,077,616	25
1977	826,535	291,813	1,118,348	26

Source: Southern Pulpwood Production, Southern Forest Experiment Station, New Orleans, Louisiana, 1957 to 1977.

Figure 2
ROUND PULPWOOD PRODUCTION IN THE 13-COUNTY AREA,
1957 to 1977

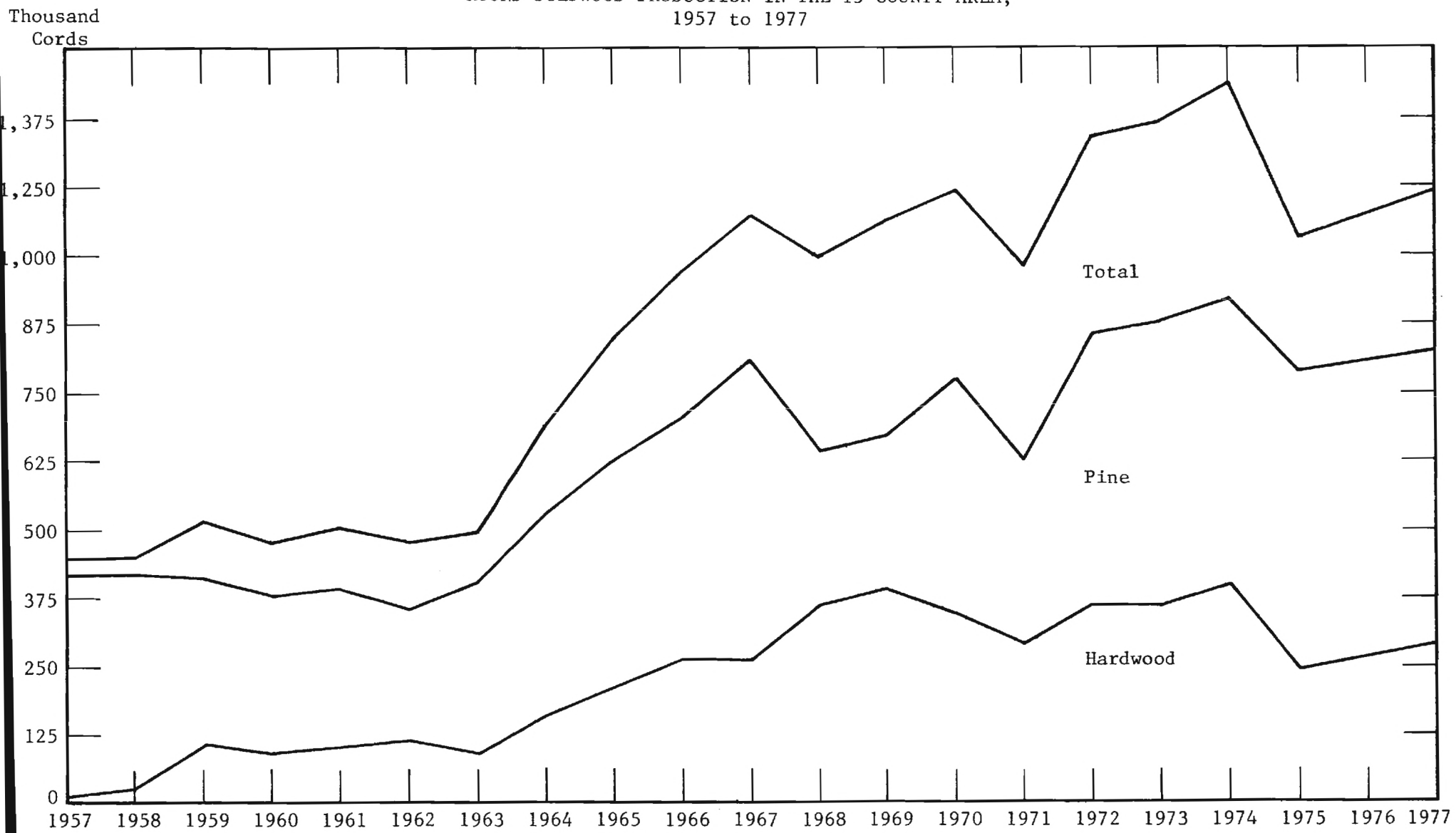


Table 13

PINE AND HARDWOOD LUMBER PRODUCTION IN THE 13-COUNTY AREA, ALABAMA, 1962 to 1977

(in millions of board-feet)

Year	Pine	Hardwood	Total	Hardwood as a % of Total
1962	119.9	59.4	179.3	33
1963	141.9	55.9	197.8	28
1964	139.8	48.1	187.9	26
1965	147.2	54.7	201.9	27
1966	220.8	59.8	280.6	29
1967	149.3	44.4	193.7	23
1968	162.6	37.4	200.0	19
1969	186.8	45.2	232.0	19
1970	143.7	37.1	180.8	21
1971	172.7	30.0	202.7	15
1972	176.4	39.3	215.7	18
1973	183.1	50.9	234.0	22
1974	178.0	59.7	237.7	25
1975	156.1	33.5	189.6	18
1976	188.0	44.9	232.9	19
1977	170.3	46.4	216.7	21

Source: Alabama Forestry Commission, Production of Forest Products by Counties in Alabama as Determined from Forest Products Severance Tax Receipts, 1962 to 1977.

Figure 3

PINE AND HARDWOOD LUMBER PRODUCTION IN THE 13-COUNTY AREA, 1963 to 1977

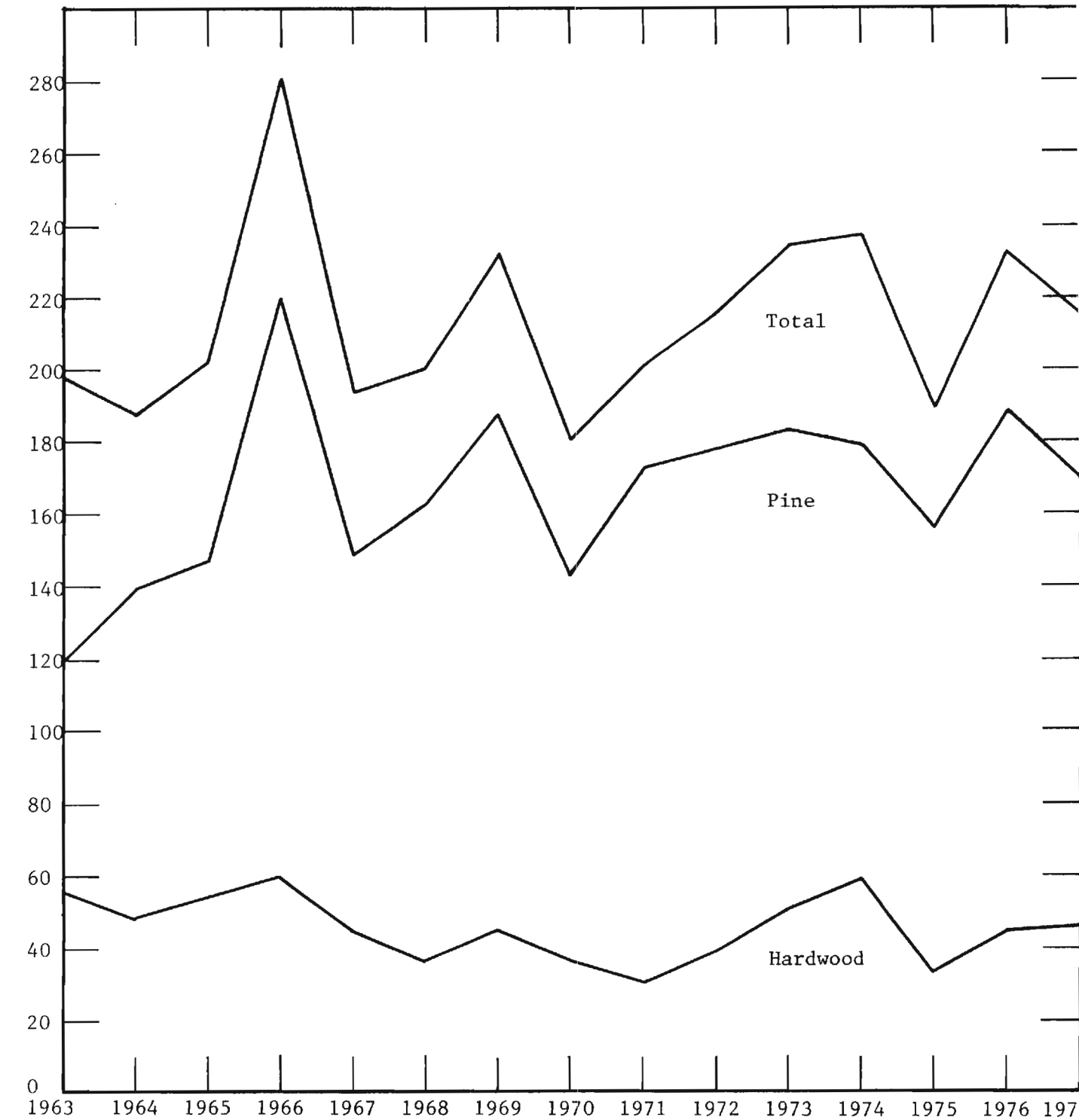


Table 14

PULPWOOD CHIPS PRODUCTION IN THE 13-COUNTY AREA,
1968 to 1977

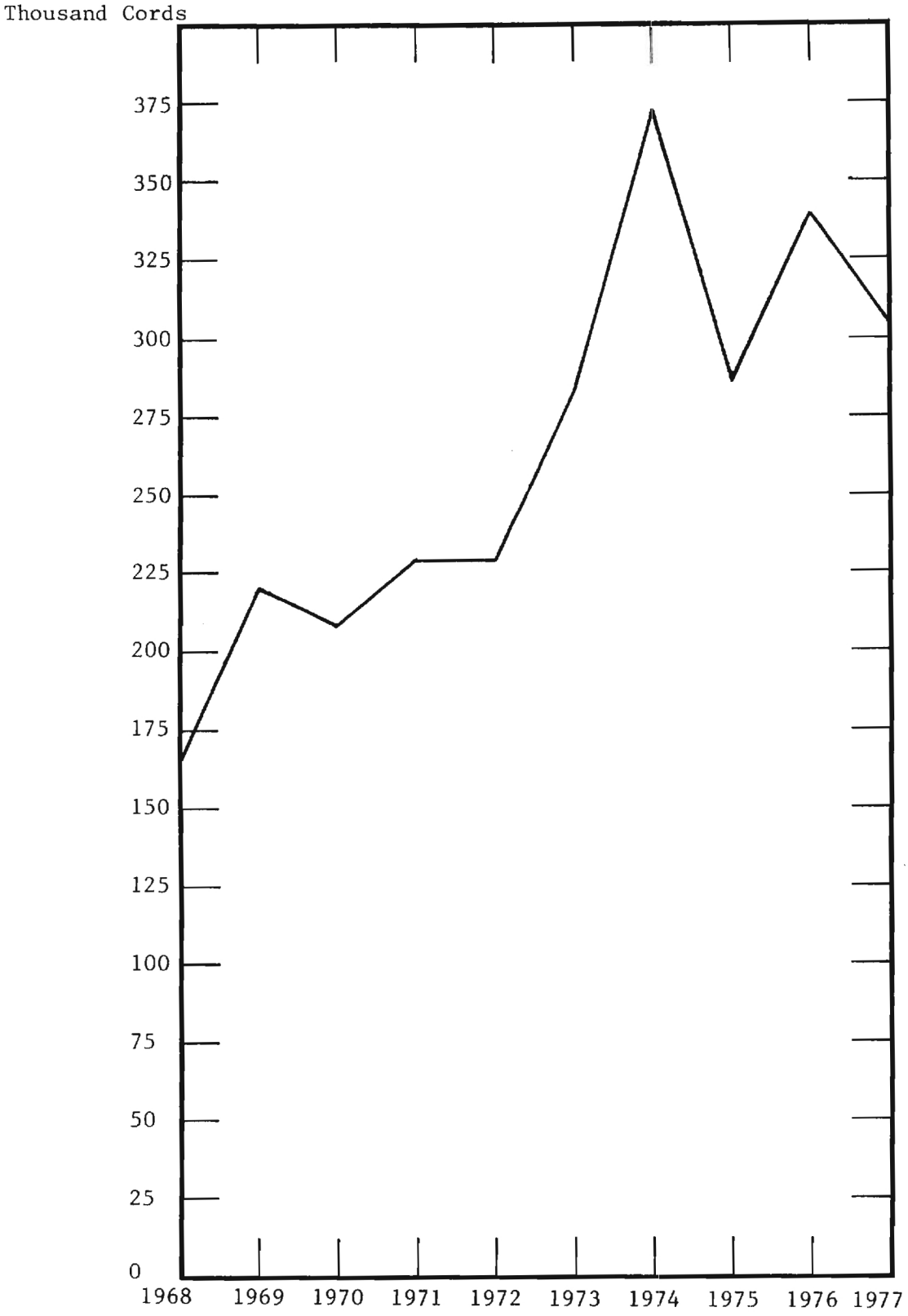
(in thousands of cords)1/

Year	Total
1968	166.0
1969	219.7
1970	208.6
1971	229.4
1972	229.0
1973	281.7
1974	372.5
1975	286.4
1976	340.0
1977	304.9

1/ 5,000 pounds = one cord

Source: Alabama Forestry Commission, Production of Forest Products by Counties in Alabama as Determined from Forest Products Severance Tax Receipts, 1968 to 1977.

Figure 4
PULPWOOD CHIPS PRODUCTION IN THE 13-COUNTY AREA,
1968 to 1977



POTENTIAL SOURCES OF WOOD FUEL SUPPLIES

The potential sources of wood fuel supplies for any given location come mainly from three categories: mill residues, forest residues, and whole-tree chipping. Mill residues are wood wastes generated either by primary wood using concerns such as pulpmills and sawmills or by secondary woodworking concerns such as furniture plants and cabinet shops. Forest residues consist of logging residues and cull trees. Logging residues refer to the parts of trees left behind after logging operations in a forest. Cull trees are diseased or dead trees. Whole-tree chipping is a new approach which was a newly developed and fully mechanized system of harvesting wood chips directly in the forest.

The potential supplies of wood materials for fuel purposes from the three main sources are discussed separately below. Factors affecting the supplies of these wood-fuel materials are too many and too volatile to be described within the scope of this study.[1/] For the purpose of this study, a 50-mile radius of Troy, Alabama is used as the base area for estimating the three categories of potential supplies.

Mill Residues

Residues at wood processing plants represent a significant wood resource in the United States. A typical sawmill operation produces 40% lumber, 11% bark, 10% planer shavings, 26% trimmings, and 13% sawdust.[2/] In secondary manufacturing, wood residues are created in several ways when lumber is converted to wood products. A fair amount of lumber is lost during the

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[1/] Factors such as the prices of different fuels, the prices of timber stumpage and forest products, national economic conditions, forest management practices, timber owners' attitude, weather and road conditions, and logging practices, to mention a few all affect the potential supplies of wood materials as fuel.

[2/] Stanley E. Couder, Wood and Bark as Fuel, Research Bulletin 14, Oregon State University, Couvallis, Oregon, 1973.

initial conversion from boards to rough product blanks. Wood also is lost by rejecting defective bark during the manufacturing process. A lot of wood is removed in the form of sawdust and shavings when machining the wood parts. By combining these waste factors that are given, the yields in different processing levels can be estimated: initial processing yield, 55%; the defective yield, 90%; and machining yield, 57%. The combined lumber yield is (0.55 x 0.90 x 0.57 = 0.28) 28%. This means that for each 1,000 board-feet of lumber that are processed, only 280 board-feet remain in the product while 720 board-feet are turned to wood waste.[3/]

Mill residues used to be abundant at both primary and secondary wood processing plants and posed a disposal problem to most mill operators. However, with the increased utilization of mill residues in recent years, especially after the Arab nations' oil embargo in 1973, these unused wood residues have been disappearing rapidly because of their low cost, the high quality of certain kinds, and their concentrations in wood processing plants.

To ascertain the availability of mill residues in the Troy area, a mail survey was conducted in November and December 1979. A questionnaire, together with a cover letter and a return envelope, was sent to each of the 122 wood processing plants located in the study area. Six questionnaires could not be delivered because of mill closures, relocations, or insufficient addresses. Of the 116 mills which received questionnaires, 43 responded by the end of November 1979 -- a return rate of 37%. Statistics on questionnaire delivery are given in Table 15.

Of the 43 mills responding, 32 of them do generate wood residues and 11 mills do not. Those firms which do not generate mill residues are engaged in logging operations or in the log and pulpwood trade. Of the 32 wood residue generating plants, 16 of them do have available wood residues for sale, while the other half have no uncommitted wood residues for sale. (See Table 16.)

[3/] J. A. Ekwall, "Estimating Wood Fuel Production at Secondary Manufacturers," a paper presented at Wood Fuel For Small Industrial Energy Users, October 2-3, 1979, James S. McKimmon Center, North Carolina State University, Raleigh, N.C.

Table 15

QUESTIONNAIRE DELIVERY FOR A WOOD RESIDUE SURVEY IN A 50-MILE RADIUS OF TROY, ALABAMA, 1979

Kind of Wood Processing	Sent	Not Delivered	Delivered	Responded
Primary plants	80	3	77	27
Secondary plants	42	3	39	16
Total	122	6	116	43

Table 16

GENERATION AND AVAILABILITY OF WOOD RESIDUES BY SURVEY RESPONDENTS, 1979

Kind of Wood Processing	Wood Residue Generating			Do Not Generate Mill Residue
	Total	Not Available	Available	
Primary plants	18	12	6	9
Secondary plants	14	4	10	2
Total	32	16	16	11

Of the 32 companies generating wood residues, only 29 actually reported their volume; three of them did not give their volume either on wood residues or on their main products. Table 17 is a tabulation of wood residues based on the type of primary or secondary processing, kind of wood residues, and methods of disposal of each reporting company.

Seventeen of the reporting companies are in primary processing, such as lumber, crossties, plywood, paper, poles, and pallets. These 17 primary wood processing companies generate 1,102,887 tons of wood residues a year. Bark and sawdust constitute about 52% of the total; wood chips, 43% of the total; shavings, 3%; and trims, slabs and scraps, 2%. Two large companies produce about 68% of the total wood residue volume generated by primary processing.

Twelve reporting companies are engaged in secondary wood processing operations, such as furniture, fixtures, dimensional stock, wood doors, and roof trusses. These 12 secondary processing plants generate 7,276 tons of wood residues a year. Trims, slabs and scraps constitute 44% of the total; sawdust, 34%; wood floor, 18%; shavings, 3%; others, 1%. Two of these companies contribute about 87% of the total wood residue volume generated by secondary processing.

The combined wood residues volume generated by both primary and secondary processing plants is 1,110,163 tons a year, with primary processing accounting for a little over 99% of the total volume. It should be noted that this total wood residue volume is based on a 37% survey response. Thus, it is reasonable to assume that the wood residue volume reported by wood processing plants in a 50-mile radius of Troy, Alabama, could be doubled if the return rate were 100%. Detailed statistics on the residues are given in Table 17.

The methods of disposing of wood residues reported by survey respondents are indicated in the same table. Three disposal methods are used: sold, burned as fuel, and piled up or hauled off. The majority of primary processing mills sold their residues, while the majority of secondary processing plants simply piled up or hauled off their wood wastes. Six of 29 reporting companies do use their wastes as fuel.

Unused or uncommitted wood residues were the focal point of this research effort. These uncommitted wood residues can be obtained through purchase or other means to be used as fuel material for a wood energy demon-

Table 17

WOOD RESIDUES GENERATED IN PRIMARY AND SECONDARY PROCESSING PLANTS
BY SURVEY RESPONDENTS IN A 50-MILE RADIUS OF TROY, ALABAMA, 1979
(in tons per year)

Primary Processing/Type	Bark	Sawdust	Mixed Bark & Sawdust	Shavings	Chips	Trims, Slabs & Scraps	Wood Flour	Total	Methods of Disposal: Sold	Burned As Fuel	Piled Up or Hauled Off
Lumber and crossties	750	1,750	-	-	4,500	150	-	7,150	x		
Lumber and crossties	-	-	125	-	3,600	-	-	3,725	x		
Lumber	1,080	2,000	-	-	-	-	-	3,080			x
Preserved lumber	-	260	-	-	-	-	-	260			x
Paper	-	-	600	-	2,000	-	-	2,600			x
Lumber, plywood & paper	253,125	68,125	-	-	-	-	-	321,250	x	x	x
Lumber	1,500	2,650	-	-	4,200	-	-	8,350	x		
Lumber and crossties	-	-	10,000	-	13,125	-	-	23,125	x		
Lumber	-	-	12,500	5,000	15,000	-	-	32,500	x	x	
Pine dimension	8,741	2,860	7,232	-	53,084	-	-	71,917	x		
Plywood and lumber	100,000	20,000	-	16,500	295,500	-	-	432,000	x		
Lumber	11,500	5,720	-	-	15,000	-	-	32,220	x	x	
Lumber	-	10,000	-	5,000	10,000	-	-	25,000	x		
Lumber	7,800	26,160	-	-	25,200	26,400	-	85,560	x	x	
Poles	-	-	-	10,400	-	-	-	10,400	x		
Lumber, crossties & pallets	-	10,000	-	-	25,000	-	-	35,000	x		
Lumber and crossties	-	-	6,250	-	2,500	-	-	8,750	x		
SUBTOTAL	384,496	149,525	36,707	36,900	468,709	26,500	-	1,102,887			
SECONDARY PROCESSING/TYPE											
Wood columns and posts	-	-	-	-	-	-	1,300	1,300	x		
	-	-	10	-	-	-	-	10		x	
Furniture	-	40	-	-	-	-	-	40			x
Furniture	-	-	-	-	-	60	-	60			x
Exterior blinds	-	88	-	-	-	-	-	88			x
Hardware dimension	-	192	-	220	-	-	-	412		x	x
Cabinets	-	1	-	-	2	-	-	3			x
Millwork	-	2	-	-	-	7	-	9			x
Furniture components	-	109	-	-	-	150	-	259			x
Wood doors	-	-	55	-	-	-	-	55			x
Roof trusses	-	2,000	-	-	-	3,000	-	5,000			x
Bark and mulch	10	10			20			40	x		x
SUBTOTAL	10	2,442	65	220	22	3,217	1,300	7,276			
TOTAL	384,506	151,967	36,772	37,120	468,731	29,767	1,300	1,110,163			

stration center in Alabama. Six primary processing plants and ten secondary processing plants have reported their unused or uncommitted volume of wood residues. A tabulation of the unused wood residues available in the study area reported by these 16 companies is given in Table 18. The tabulation is broken down by primary and secondary processing and by the types of wood residues generated. Primary processors generate 49,715 tons of unused wood residues a year, of which bark and sawdust contribute 87% and wood chips compose 13%. One company contributes 63% the total volume.

Secondary processors generate 5,634 tons of unused wood residues a year. Of the total volume, trims, slabs and scraps contribute 57%, sawdust, 41%; and the balance of 4% comprises bark, shavings and chips. One mill contributes 89% of the total volume generated by secondary processing. It should be noted that wood residues from secondary processing operations are generally dry with moisture content of 7% to 15%, while wood residues from primary processings are green with moisture content of about 50%.

The combined volume of unused wood residues generated by primary and secondary processing activities in the study area is 55,349 tons a year, with primary processors contributing 90% of the total. Bark and sawdust constitute 82% of the combined total; wood chips, 12%; trims, slabs and scraps, 6%; shavings, 0.1%. It again should be noted that this unused volume is based on a 37% survey return, and that a 100% response probably would double the residue volume to an estimated 110,000 tons annually in the study area. It is also apparent from the tabulation that primary processing operations are the main sources of supply of mill residues. The residues are highly concentrated in the hands of a small number of wood processing plants. This concentration would make it easier for a potential user to procure these wood residues.

The total unused volume of 55,349 tons constitutes only about 5% of the total volume of wood residues generated and reported (1,110,163 tons) in the study area. This survey reveals that wood residues are not as abundant now as formerly. Any potential user of wood residues needs to investigate closely the supply sources in a specific area before a project is committed.

Only two survey respondents gave the prices of wood residues available for sale. A primary wood processing plant reported $15/ton on wood chips, $6.50/ton on bark, and $6.50/ton on sawdust, all f.o.b. mill. A secondary wood processing plant reported $9/ton on sawdust and $5/ton on slabs, f.o.b.

Table 18

UNUSED RESIDUES AVAILABLE AT PRIMARY AND SECONDARY PROCESSING PLANTS
BY SURVEY RESPONDENTS IN A 50-MILE RADIUS OF TROY, ALABAMA, 1979
(In Tons Per Year)

Primary Processing/Type	Bark	Sawdust	Mixed Bark & Sawdust	Shavings	Chips	Trims, Slabs & Scraps	Total
Lumber and crossties	750	1,750	-	-	4,500	-	7,000
Lumber and crossties	-	-	5,625	-	-	-	5,625
Lumber	1,080	2,000	-	-	-	-	3,080
Preserved lumber	-	260	-	-	-	-	260
Paper	-	-	600	-	2,000	-	2,600
Lumber, plywood & paper	20,250	10,900	-	-	-	-	31,150
Subtotal	22,080	14,910	6,225	0	6,500	0	49,715
Secondary Processing/Type							
Furniture	-	40	-	-	-	-	40
Furniture	-	-	-	-	-	60	60
Exterior blinds	-	88	-	-	-	-	88
Hardwood dimension	-	50	-	50	-	-	100
Cabinets	-	1	-	-	2	-	3
Millwork	-	2	-	-	-	7	9
Furniture components	-	109	-	-	-	150	259
Wood door	-	-	55	-	-	-	55
Roof trusses	-	2,000	-	-	-	3,000	5,000
Bark and mulch	10	10	-	-	-	-	20
Subtotal	10	2,300	55	50	2	3,217	5,634
Total	22,090	17,210	6,280	50	6,502	3,217	55,349

mill. Most survey respondents left price questions unanswered.

Forest Residues

As indicated previously, forest residues consist of logging residues plus other unused materials in the woods not directly related to the logging operation. Logging residues generally are tops, limbs, branches, stumps, and trees felled but left behind after logging. Other forest residues unrelated to logging are trees damaged by insects, disease, and fire. These cull trees constitute a major portion of forest residues, especially in hardwood timber. Data on cull trees is less clear and accurate than on logging residues, which are obvious and concentrated in areas where logging is taking place.

In a study concerning wood energy utilization in Georgia, the Engineering Experiment Station, Georgia Institute of Technology, developed a multiplier method for estimating forest residues.[4/] The method is based on a relationship between the amount of commercially harvested wood and the amount of wood energy materials left behind in forests. The wood that would be recovered as energy wood in a harvesting operation includes the portion of commercial grade timber which is unused, e.g., stumps, tops, and minor limbs. The other portion is from nearby rough, rotten, and small (less than 5 inches d.b.h.) trees.

Studies done by the Southeastern Forest Experiment Station on softwood and hardwood were used as the basis for developing separate multipliers.[5/] The ratios of biomass used (commercial harvested logs) and biomass unused (forest residues plus small trees) are estimated. For softwood, the ratios

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[4/] A Feasibility Study for Wood Energy Utilization in Georgia, prepared for the Georgia Forestry Commission by the Economic Development Laboratory and Energy Research Laboratory, Engineering Experiment Station, Georgia Institute of Technology, Project A-2140, August 1979.

[5/] Joe P. McClure, Noel D. Cost, and Herbert A. Knight, "Multiresource Inventories-A New Concept for Forest Survey (First Draft)", U.S.D.A., Forest Service, Southeastern Forest Experiment Station, Asheville, North Carolina, 1979, p. 90.

Noel D. Cost, "Aboveground Volume of Hardwoods in the Mountain Region of North Carolina," U.S.D.A., Forest Service, Southeastern Forest Experiment Station, Asheville, North Carolina, November 1978.

are 71.7% vs. 28.3%. For hardwood, the ratios are 57.12% vs. 42.88%. The unused biomass consists of stumps, tops and minor limbs, rough and rotten trees, and trees with less than 5 inches d.b.h. The detailed ratios of biomass used and biomasss unused together with the percentage breakdown of unused biomass on both softwood and hardwood are presented in Table 19.

Table 19

RATIOS OF BIOMASS USED AND UNUSED AND THE PERCENTAGE BREAKDOWN OF UNUSED BIOMASS, ABOVEGROUND, FOR SOFTWOOD AND HARDWOOD

	Softwood	Hardwood
Biomass Used	71.70	57.12
Biomass Unused*	28.30	42.88
Total	100.00	100.00
Percentage Breakdown of Unused Biomass:		
Stump	15.97	9.36
Tops and minor limbs	32.84	18.88
Rough and rotten trees	8.84	33.43
Less than 5" d.b.h. trees	42.35	38.33
Total	100.00	100.00

*Does not include shrubs, vines and leaves.

Source: A Feasibility Study for Wood Energy Uilization in Georgia.

Based on the published data on pulpwood production (Table 12), and lumber production (Table 13) in the study area, the volume of forest residues in the same area can be estimated by using the ratios and multipliers provided in Table 19. In 1977, pulpwood production was 826,535 cords in pine and 291,813 cords in hardwood, while lumber production was 170.3 million board-feet in pine and 46.4 milliom board feet in hardwood. The volume was converted into weight by using 5,500 pounds per cord and 10,000

pounds per thousand board feet on both softwood and hardwood.[6/] The conversion of volume to weight is given in Table 20.

Table 20

THE CONVERSION OF PULPWOOD AND LUMBER PRODUCTION FROM VOLUME TO WEIGHT IN A 50-MILE RADIUS OF TROY, ALABAMA, 1977

Kind	Pine	Hardwood
Pulpwood	826,535 cords	291,813 cords
Lumber	170.3 million bd.ft.	46.4 million bd.ft.
Conversion		
Pulpwood (5,500 lbs./cord)	4,545,942,500 lbs.	1,604,971,500 lbs.
Lumber (10,000 lbs./M bd.ft.)	1,703,000,000 lbs.	464,000,000 lbs.
Total	6,248,942,500 lbs.	2,068,971,500 lbs.

The combined weight of pine pulpwood and lumber production was estimated at 6,248,942,500 pounds or 3,124,471 tons, and the combined weight of hardwood pulpwood and lumber production was estimated at 2,068,971,500 pounds or 1,034,486 tons. These converted tonnages represent biomass used (harvested logs) in 1977 in a 50-mile radius of Troy, Alabama. By using the ratios of biomass used and unused and the multipliers developed for softwood and hardwood (Table 19), forest residues of different kinds can be estimated. These estimates provide a rough indication of the amount of each kind of forest residue potentially available for fuel purposes. Forest residues in stumps, tops and minor limbs, and rough and rotten trees were estimated by weight for softwood and hardwood. (See Table 21.) However, trees with

[6/] Williams, David L. and William C. Hopkins, Converting Factors For Southern Pine Products, Agricultural Experiment Station, Louisiana State University, Bulletin No. 626, March 1969. Volume Tables, Converting Factors, and Other Information Applicable to Commercial Timber in the South, Division of State and Private Forestry, U.S. Forest Service, Region 8, Atlanta, Georgia, May 1959.

less than 5 inches d.b.h. are not included in the estimates because these small trees should be left in the forest to ensure future growing stock.

Total forest residues were estimated at 1,187,877 tons without rounding off, with softwood constituting nearly 60% and hardwood 40%. The details of the estimates are given in Table 21. It should be noted that the volume of forest residues is directly tied in with logging operations; the greater the production of pulpwood and lumber, the larger the volume of forest residues which would be generated. In 1977, the total volume of forest residues was slightly over the total volume of mill residues generated (Table 17) in the study area. However, the utilization of forest residues is severely hindered by the high costs of harvesting, transporting, and processing the variety of forest residue materials. Overcoming these costs is both a challenge and an opportunity in the development of wood as a future source of fuel energy.

TABLE 21

ESTIMATED FOREST RESIDUES IN A 50-MILE RADIUS OF TROY, ALABAMA, 1977

(in tons)

Kind	Softwood	Hardwood	Total
Biomass Used	3,124,471	1,034,486	4,158,957
Biomass Unused	1,233,229	776,589	2,009,818
Breakdown of Unused Biomass:			
Stumps	196,946	72,688	269,634
Tops and minor limbs	404,992	146,620	551,612
Rough and rotten trees	107,018	259,613	366,631
Less than 5" d.b.h. trees	-	-	-
Total	708,956	478,921	1,187,877

Whole-Tree Chipping

In addition to mill residues and forest residues, whole-tree chipping offers another possibility as a source of wood for energy purposes. Whole-

tree chipping was developed originally to produce wood chips for pulpmills, and the system has become well established in recent years. The rapid increase in fossil fuel costs since the Arab oil embargo in 1973 has made wood chips a distinct possibility for fuel-energy use. The raw material for whole-tree chipping could come from forest thinning, cull trees, or even from trees cultivated especially for energy purposes.

New machinery developed for whole-tree chipping consists of the feller-buncher, grapple skidder, and total tree chipper. A feller-buncher machine can shear trees (up to 20 inches in diameter) off at ground level, grasp the trees several at a time, and carry the stems to a convenient area for accumulation where they are laid down horizontally. These trees have to be moved to a chipping area rapidly. This task is usually performed by a grapple skidder, a tracked or rubber-tired vehicle specially built for pulling bunches of logs through the forest. Chipping is done by a whole-tree chipper, which can be portable (mounted on a semi-trailer) or installed in a more or less permanent location. The total tree chipper will pull an entire tree into the chipping blades and reduce it to small pieces which are blown into a waiting truck. The chipper is generally powered by a diesel engine and is available in sizes capable of chipping trees approximately 10 inches in diameter up to 20 inches in diameter. The process of whole-tree chipping is illustrated in Figure 5.

Whole-tree chipping can be carried out in different ways such as clear-cutting all trees, selective thinning of a dense forest, or timber stand improvement by cutting down the undesirable trees of culled, diseased, and noncommercial species. Although the whole-tree chipping technology is still being tested and developed, its practical implementations have been widely recognized and put to use.

The economics of a whole-tree chipping operation, based on a 1979 Georgia Tech study, is outlined in Table 22. In 1979, the costs of producing whole-tree chips were estimated at $14.92 to $19.37 per ton, depending upon stumpage price. Whole-tree chips contain 4,500 Btu per pound with 50% moisture content; Thus, whole-tree chips would cost $1.66 to $2.15 per million Btu. Whole-tree chips are competitive with other reported fuel costs, on a per-million-Btu basis: electricity, $12.76; oils, $5.04; propane, $5.65; and natural gas, $3.53. (See Table 32.)

Table 22

ESTIMATED PER-TON COST OF A WHOLE-TREE CHIPPING OPERATION, 1979

Productivity: 62.5 tons/hour; 125,000 tons/year

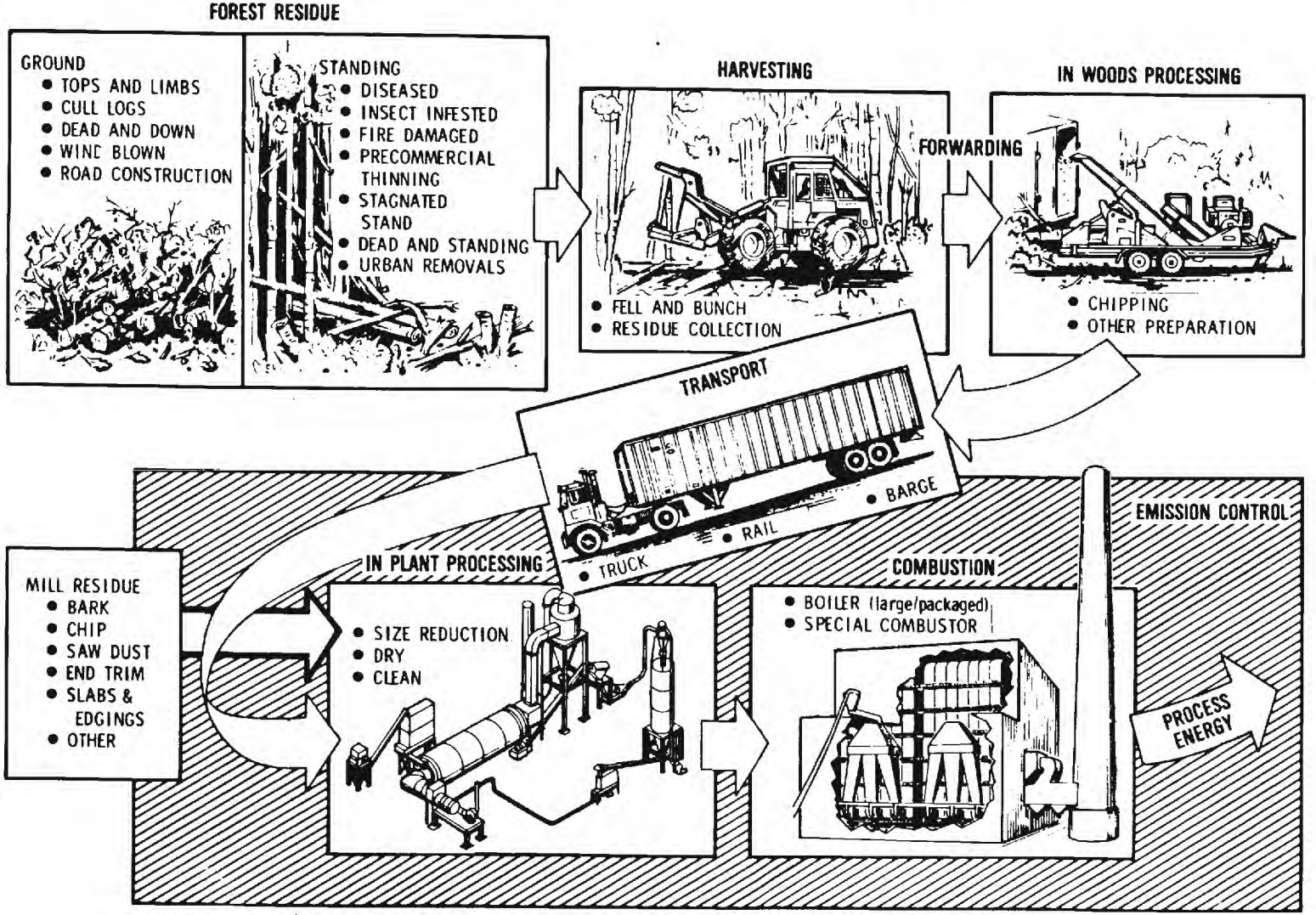
Equipment (fixed and operating costs, excluding labor)		
2 Bobcat feller-bunchers		$ 0.61
2 grapple skidders		0.70
1 mobile chipper		0.58
Support equipment (2 pickup trucks, crew truck, chain saws, backup skidder, tractor-crawler, knife grinder)		0.95
		2.84
Transportation (20 loads, 50 miles one way, per day @ $0.67/mile): 5 to 6 tandem diesel truck tractors plus chip vans		2.68
Labor: 6 drives @ $250/week, 7 loggers @ $250/week, 2 foremen @ $350/week		1.58
Workmen's Compensation		.28
Insurance		.40
Benefits		.40
Overhead		.88
Profit and Taxes (20% of equiment, transportation, labor)		$ 1.42
Subtotal		$10.48
Stumpage* (low-high range	4.44 to	8.89
Total	$14.92 to	$19.37/ton

*Stumpage prices based on pine (softwood) prices.

Source: A Feasibility Study for Wood Energy Utilization in Georgia.

Figure 5

Residue Fuel Flow Concepts



According to unpublished data on file at the U.S.D.A. Forest Service Office in Washington, D.C., about 15% of the trees remain in the forest because they are dead, diseased, or crooked. Another 10% are too small to be sawed into lumber and are used for pulpwood.[7/] In 1975, there were 233.4 million cubic feet of growing stock in the study area. If only 5% of these stocks were harvested for energy purposes per year, the yield would amount to 11.67 million cubic feet or in terms of weight, approximately 175,369 tons.[8/] Growing stock is living trees, excluding cull trees, which constitute about 15% of the trees in a forest, as mentioned. Cull trees are considered forest residues, which were estimated along with logging operations in the previous section.

In summary, the potential supplies of wood fuel in a 50-mile radius of Troy, Alabama, present a mixed picture. Unused and uncommitted mill residues, with 55,000 tons reported and 110,000 tons estimated, constitute only about 5% of the total mill residues generated in the area annually. Forest residues, with 1,188,000 tons estimated annually, are the largest potential supplies of wood fuel in the area, but this source has not yet been tapped for utilization. Whole-tree chipping is a new technology. On a sustained yield basis, the area could afford to produce 175,000 tons a year.

In terms of heating value, bark yields about 8,000 to 10,000 Btu per pound of bone dry material, depending on species. Pine bark with 50% moisture content has about 3,500 Btu per pound.[9/] Dry softwoods have a similar heating value of approximately 9,000 Btu per pound. Dry hardwoods have a heating value of approximately 8,000 Btu per pound.[10/] Other properties of wood fuel, such as moisture content, heating value, and bulk density, are given in Table 23.

[7/] Gerald A. Koenighshof, "Status of Com-Ply Floor Joist Research," Forest Products Journal, Vol. 29, No. 11, November 1979.

[8/] Based on the conversion factors of 183 cubic feet per thousand board feet, International scale and 5,500 pounds per thousand board feet.

[9/] Bark and Its Possible Uses, U.S. Department of Agriculture, Forest Service Research Note FLP-091, Madison, Wisconsin, October 1969.

[10/] A Feasibility Study for Wood Energy Utilization in Georgia.

Table 23

HEATING VALUE RELATIVE TO MOISTURE CONTENT AND BULK DENSITY OF DIFFERENT WOOD FUEL

Wood Fuel	Moisture Content, Wet Basis	Higher Heating Value, (Btu per lb.)	Bulk Density ($lbs/ft.^3$)
Whole Tree Chips	50%	4,500	24.0
Dry Planer Shavings	13%	7,800	6.0
Green Sawdust	50%	4,500	20.0
Dry Sawdust	13%	7,800	11.5
Wood Pellets	10%	8,100	35.0

Source: A Feasibility Study for Wood Energy Utilization in Georgia.

ENERGY-USE PATTERNS AND PERSPECTIVE

An Energy-Use Survey

A survey on energy use patterns was conducted in October and November 1979 to gather data on current uses of fuel, equipment involved, fuel costs, and the prospects for wood as a source of fuel in the study area. A mailing list containing 2,982 names and addresses of manufacturing firms, institutions, commercial concerns, and residences was prepared. A questionnaire was designed and field-tested in the study area. Finally, a questionnaire, together with a cover letter and a stamped, self-addressed return envelope, was sent to each name on the mailing list.

The numbers of questionnaires sent, delivered, returned, and tabulated under the main categories mentioned are given in Table 24. About 22% of the questionnaires were delivered to manufacturing establishments, 32% to institutions, 26% to commercial concerns, and 20% to residences. Of the 182 that responded, 164 were tabulated. The balance of 18 arrived too late to be included in the tabulation. Among the tabulated questionnaires, manufacturing constituted 26%; institutions, 27%; commercial concerns, 21%; and residences, 26%.

Table 24

NUMBER OF QUESTIONNAIRES SENT, DELIVERED, RETURNED AND TABULATED FOR AN ENERGY-USE SURVEY, 1979

Category	Sent	Delivered	Returned	Tabulated
Manufacturing	641	625	50	42
Institutional	932	900	47	45
Commercial	795	746	37	35
Residential	614	555	48	42
Total	2,982	2,826	182	164

The types of manufacturing firms that responded to the survey included concrete products, farm instruments, pneumatic equipment, wood processing, building components, steel vehicles, textiles, food mixing, plastics, soft drinks, printing, and sawmill equipment.

Institutional respondents included schools, religious organizations, health organizations, and government agencies. Commercial respondents comprised drinking and eating places, utilities, financial institutions, and radio stations. Residential respondents were individual families living in the study area.

Survey results were tabulated according to fuel type and equipment, fuel costs, wood as a potential source of fuel, and comments. These factors are discussed separately below.

Fuel Type and Equipment

The numbers of each type of equipment reported in the survey are presented by equipment category, fuel type, and reporting source in Tables 25 to 31. Major equipment and energy instruments are grouped as boilers, stoves, heaters (including water heaters), furnaces, ranges, dryers, and other equipment. Reported fuels include natural gas, oil, propane, electricity and wood. Reporting sources refer to manufacturing, institutional, commercial, and residential respondents.

From the results of the tabulation, it is obvious that natural gas is the leading source of energy used in all equipment categories except "other equipment." Electricity is the second most important source of energy in all but boilers. Propane is a relatively significant source of energy for heating purposes, and it is being used in all equipment categories. Oil is an important source of energy only for boilers. Perhaps wood is the least important source of energy fuel among survey respondents; however, it is cited in four equipment categories out of a total of seven.

Boilers are more frequently used by manufacturing and institutional concerns than by either commercial or residential respondents, while heaters, furnaces, and ranges are used predominatly by residential households. Dryers are largely used by manufacturing concerns and fueled by natural gas; residential, institutional, and commercial respondents use dryers powered by electricity.

The "other equipment" category presented in Table 30 varies according to responding sources. The specific equipment involved in each category is listed in the footnotes to the table.

Table 25

NUMBER OF REPORTED BOILERS BY FUEL TYPE AND BY REPORTING SOURCE

Type of Fuel	Manufacturing	Institutional	Commercial	Total
Natural Gas	6	27	4	37
Oil	11	1	-	12
Propane	2	-	-	2
Electricity	-	-	-	-
Wood	4	-	-	4
Total	23	28	4	55

Table 26

NUMBER OF REPORTED STOVES BY FUEL TYPE AND BY REPORTING SOURCE

Type of Fuel	Manufacturing	Institutional	Commercial	Total
Natural Gas	3	11	2	16
Oil	1	-	-	1
Propane	-	-	2	2
Electricity	-	9	1	10
Wood	3	-	-	3
Total	7	20	5	32

Table 27

NUMBER OF REPORTED HEATERS BY FUEL TYPE AND BY REPORTING SOURCE

Type of Fuel	Manufacturing	Institutional	Commercial	Residential	Total
Natural Gas	21	85	10	253 + 268*	369 +
Oil	9	-	-	1	10
Propane	9	97	3	8 + 1*	17 +
Electricity	226	10	3	144 + 161*	383 +
Wood	2	-	-	-	2
Total	267	192	16	406 + 430*	881 +

*Hot Water Heater

Table 28

NUMBER OF FURNACES BY FUEL TYPE AND BY REPORTING SOURCE

Type of Fuel	Manufacturing	Institutional	Commercial	Residential	Total
Natural Gas	104	-	-	-	104
Oil	1	-	-	-	1
Propane	2	-	-	-	2
Electricity	1	3	1	23	28
Wood	-				
Total	108	3	1	23	135

Table 29

NUMBER OF REPORTED RANGES BY FUEL TYPE AND BY REPORTING SOURCE

Type of Fuel	Manufacturing	Institutional	Commercial	Residential	Total
Natural Gas	-	14	2	203	219
Oil	-	-	-	-	-
Propane	-	11	-	-	11
Electricity	1	4	1	153	159
Wood	-	-	-	-	-
Total	1	29	3	356	389

Table 30

NUMBER OF REPORTED DRYERS BY FUEL TYPE AND BY REPORTING SOURCE

Type of Fuel	Manufacturing	Institutional	Commercial	Residential	Total
Natural Gas	104	-	-	-	104
Oil	1	-	-	-	1
Propane	2	-	-	-	2
Electricity	1	3	1	23	28
Wood	-	-	-	-	-
Total	108	3	1	23	135

Table 31

NUMBER OF REPORTED OTHER EQUIPMENT BY FUEL TYPE AND BY REPORTING SOURCE

Type of Fuel	Manufacturing[1/]	Institutional[2/]	Commercial[3/]	Residential[4/]	Total
Natural Gas	5	24	19	-	48
Oil	1	-	-	-	1
Propane	3	4	1	-	8
Electricity	19	8	25	7	59
Wood	1		1	5	7
Total	29	36	46	12	123

[1/] Reported are wood chippers, debarkers, sawmill electric motors, smokehouse ovens, and mills.

[2/] Reported are steam cleaners, deep fat fryers, washing machines, incinerators, and heat pumps.

[3/] Reported are open pit grills, heat pumps, transmitters and fryers.

[4/] Reported are wood fireplaces, electric washers, electric water pumps, air conditioners, and freezers.

Fuel Costs

Fuel costs reported by survey respondents were converted on the basis of costs per million Btu and then tabulated according to fuel type and responding source. The results of the tabulation are presented in Table 32 by responding sources, by number of respondents, and in terms of cost range and average costs. A summary of the tabulation for all types of users also is presented.

It is obvious from the tables that electricity is the most expensive form of energy ranging from $9.17 to $15.67 per million Btu and with an average cost of $12.76 per million Btu. Propane is the second most expensive form of energy, although it is far less expensive than electricity on a per-million-Btu basis. Its cost ranges from $5.20 to $6.28 per million Btu, with an average of $5.65 per million Btu. Oil is the third-ranking energy source, with a cost range from $4.84 to $5.84 per million Btu and an average of $5.04 per million Btu. Natural gas is in fourth place, with cost comparisons ranging from $2.97 to $4.35 per million Btu and an average of $3.53 per million Btu.

Wood is the least expensive source of energy form, costing only $1.06 per million Btu. However, its use is reported by only one survey respondent and it is likely that the supply source is mill residues. Wood is the least used item for fuel purposes because of its bulky nature and its incompatibility with most equipment designed for other types of fuel such as electricity. However, if low-cost wood residues could be converted into electricity, the door would be wide open for reducing electricity costs through a program of wood waste utilization.

Wood as a Potential Source of Fuel

One of the survey objectives was to find out the potential uses of wood for energy purposes among the four responding categories mentioned. Respondents were asked to indicate whether they would consider using wood, the kind of wood fuel and equipment involved, the wood supply source, and the distance of the potential wood supplies.

There were 126 respondents indicating either "yes" or "no" to the potential use of wood as their fuel source. Exactly one third gave affirmative answers and two thirds were negative. None of the institutional respon-

Table 32

FUEL COSTS PER MILLION BTU FUEL TYPE AND BY RESPONDENT CATEGORY, NOVEMBER 1979

User/Fuel Type	No. Of Respondents	Cost in Dollars per Million Btu	
		Range	Average
Manufacturing:			
Natural Gas	7	2.04- 3.89	2.97
Oils	8	3.29- 5.85	4.84
Propane	4	5.57- 5.79	5.68
Electricity	3	11.72-15.79	13.76
Wood	1	-	1.06
Institutional:			
Natural Gas	9	2.26-4.50	3.35
Oils	2	5.71-6.36	5.84
Propane	3	4.91-5.79	5.20
Electricity	4	9.02-9.55	9.17
Commercial:			
Natural Gas	5	3.07- 7.40	4.35
Propane	2	6.11- 6.44	6.28
Electricity	4	13.42-17.29	15.67
Residential:			
Natural Gas	2	4.00- 4.60	4.30
Electricity	2	11.72-13.48	12.60
All Users:			
Natural Gas	23	2.04- 7.40	3.53
Oil	10	3.29- 6.36	5.04
Propane	9	4.91- 6.44	5.65
Electricity	13	9.02-17.29	12.76
Wood	1	-	1.06

dents gave an affirmative answer, while two thirds of the residential respondents gave affirmative answers. Details are given in Table 33.

Survey respondents were asked what kind of wood fuel and what type of equipment would be involved if they do decide to use wood as an energy source. No opinion was forwarded by institutional and commercial respondents. However, some opinions expressed by residential and manufacturing sources are presented in Table 34. Of the 35 residential respondents, 22 expressed a preference for wood logs, seven chose slabs, and six opted for wood chips. Among the types of equipment involved, fireplaces accounted for 23; furnaces, 5; stoves, 3; and heaters, 4. Among the 13 manufacturing respondents, none would use fireplaces. The distribution of other kinds of equipment and wood fuel types is quite even.

Table 33

OPINION OF SURVEY RESPONDENTS
CONCERNING THE POTENTIAL USE OF WOOD AS THEIR FUEL SOURCE, 1979

Respondent Category	Yes	No	Total	Percent "Yes"
Manufacturing	12	21	33	36
Institutional	0	23	23	0
Commercial	3	27	30	10
Residential	27	13	40	68
Total	42	84	126	33

Table 34

TYPE OF EQUIPMENT AND KIND OF WOOD FUEL WHICH
MIGHT BE USED BY RESIDENTIAL AND COMMERCIAL RESPONDENTS, 1979

(Number of Respondents)

Type of Equipment	Residential				Manufacturing			
	Logs	Slabs	Chips	Total	Logs	Slabs	Chips	Total
Fireplace	16	4	3	23	-	-	-	-
Furnace	2	1	2	5	-	2	1	3
Stove	2	1	-	3	2	1	1	4
Boiler	-	-	-	-	1	-	1	2
Heater	2	1	1	4	1	2	1	4
Total	22	7	6	35	4	5	4	13

Survey respondents were asked about any potential source of wood-fuel supply nearby. No answer was forwarded by institutional sources, which had a negative opinion of wood as fuel. The opinions expressed by the other three responding sources are presented in Table 35. Of a total of 76 answers, 62 were affirmative, 9 were negative, and 15 did not know whether a nearby source was available.

TABLE 35

SURVEY RESPONSES CONCERNING AVAILABILITY OF NEARBY SOURCES OF WOOD-FUEL SUPPLY, 1979

Responding Category	Yes	No	Unknown	Total
Manufacturing	25	1	4	30
Commercial	14	4	6	24
Residential	23	4	5	32
Total	62	9	15	86

Major sources of wood-fuel supply come largely from sawmills located nearby. Other supply sources are fuel wood dealers, loggers, direct purchase from timber owners, captive supplies, veneer mills, and tree surgeons. Details are given in Table 36. Residential respondents depend more on other supply sources than manufacturing and commercial respondents.

TABLE 36

SOURCES OF WOOD-FUEL SUPPLY INDICATED BY SURVEY RESPONDENTS, 1979

(Number of respondents)

Responding Category	Sawmill	Others	Total
Manufacturing	18	8	26
Commercial	12	2	14
Residential	9	16	25
Total	39	26	65

The distance of potential wood-fuel supply ranges from 0 to 50 miles, with an average distance of 11 miles for manufacturing, 6 miles for commercial

respondents, and 4 miles for residential respondents. It is conceivable that manufacturing concerns could afford to go a longer distance to get needed wood fuel than either commercial or residential users. A zero distance is apparently indicative of a captive supply. Details are given in Table 37.

TABLE 37

DISTANCE OF POTENTIAL WOOD-FUEL SUPPLIES INDICATED BY SURVEY RESPONDENTS, 1979

(in miles)

Responding Source	Range	Average
Manufacturing	0-50	11
Commercial	1-20	6
Residential	1/2-15	4

Comments

The most common objection to using wood as a fuel is the initial expense incurred in conversion. Most respondents appear to believe that their existing systems, fueled primarily by either natural gas or electricity, are adequate. They feel that conversion to wood-fuel for heating purposes is unadvisable at this time because of environmental problems and extra labor requirements which would become necessary. One respondent indicated that he was unimpressed by current wood-fuel technology.

Among the four responding sources, there is little support for wood-fuel from institutions such as churches, schools and hospitals. They cited the unsuitability of wood-fuel to their conditions. Most of the commercial respondents cited the same objections. However, strong interest in wood-fuel was indicated by residential and manufacturing respondents. Their interest stems from the availability and low cost of wood-fuel materials.

The results of the survey reveal that wood is not quite accepted as a major fuel source yet. However, interests in wood-fuel are apparently there, especially among individual households and manufacturing concerns. These two sectors of society are, in fact, the major users of all fuels and energy. In

order to create an atmosphere more conducive to wood-fuel utilization, wood-fuel combustion and handling technology must be improved. It would be better for wood-fuel to be converted into a form of energy, such as electricity, which can be accepted by many existing fuel systems without incurring high conversion costs.

MAJOR WOOD-FUEL TECHNOLOGIES

This chapter reviews major wood-fuel technologies which are potentially adoptable in a wood energy demonstration center in the study area. The review is confined to combustion technologies which are the center of attention in the selection process. Technologies concerning harvesting, transportation, storage and handling, which can be used by the lumber, pulp, paper, and board industries as well as for energy purposes, are not included in the review.

Major technologies discussed are wood-fired package boilers, suspension and cyclone burners, fluidized bed combustors, pyrolysis systems, wood gasifiers, and electric power generation. Some details of these technologies can be found in a Georgia Tech study entitled A Feasibility Study for Wood Energy Utilization in Georgia, EES Project A-2140, August 1979. Only a brief summary and comments are presented here.

Wood-Fired Package Boilers

Boilers are the main consumers of oil, natural gas, and coal for industrial purposes. Since the energy crisis in 1973, installation of wood-fired boilers has been increasing and the technology on wood-fired package boilers has been improving steadily. Although the initial installation costs of wood-fired boilers are substantially higher than those for oil- or gas-fired boilers, they are economical in the long run because of low wood-fuel costs.

In 1978, wood-fired boilers constituted about 8.7% of all boilers in Alabama and 7.7% in the eight-state Southeast in terms of the total number of boilers used for industrial purposes. (See Table 38.) In terms of aggregate capacity of industrial boilers, wood-fired boilers constituted only 3.2% in Alabama and 3.6% in the eight-state Southeast in the same year. (See Table 39.) Most wood-fired boilers are concentrated in smaller capacity ranges. The data were compiled by the U.S. Environmental Protection Agency (EPA), however, and it should be noted that EPA data dealt only with boilers having capacities above 1,000,000 Btu per hour. Although the data are not complete, they do include the major segment of the boiler population in the region.

A number of small boiler manufacturers specialize in building wood-fired package boilers. The name of each company, location, capacity range, boiler efficiency, and fuel moisture limit are given in Table 40.

Table 38

NUMBER OF INDUSTRIAL BOILERS IN THE EIGHT SOUTHEASTERN STATES AND ALBAMA, 1978

Capacity Range1/	Eight States2/			Alabama		
	All Boilers	Wood Fired	% Wood Fired	All Boilers	Wood Fired	% Wood Fired
1-30	2,369	288	9.6	33	6	18.2
31-60	532	36	6.8	40	6	15.0
61-90	255	14	5.5	49	8	16.5
90-120	161	6	3.7	24	4	16.8
121-150	147	5	3.4	44	-	-
151-180	81	1	1.2	15	-	-
181 and over	301	7	2.3	72	-	-
Total	3,846	297	7.7	277	24	8.7

1/Boiler capacity in 1,000,000 Btu/hour.
2/Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina and Tennessee.

Source: Compiled from data provided by the U.S. Environmental Protection Agency, Atlanta Regional Office, Georgia, 1978.

Table 39

AGGREGATED CAPACITY OF INDUSTRIAL BOILERS IN THE SOUTHEASTERN STATES AND ALABAMA, 1978

Capacity Range1/	Eight States2/			Alabama		
	All Boilers	Wood Fired	% Wood Fired	All Boilers	Wood Fired	% Wood Fired
1-30	24,955	2,180	8.7	499	57	1.1
31-60	23,827	1,552	6.5	1,934	313	16.2
61-90	19,202	993	5.2	3,853	581	15.1
91-120	17,101	634	3.7	2,603	403	15.5
121-150	19,926	609	3.1	5,811	-	-
151-180	13,584	170	1.3	2,466	-	-
181 and over	112,020	2,164	1.9	24,569	-	-
TOTAL	230,615	8,302	3.6	41,735	1,354	3.2

1/Boiler capacity in 1,000,000 Btu/hour.
2/Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.

Source: Compiled from data provided by the U.S. Environmental Protection Agency, Atlanta Regional Office, Georgia, 1978.

Table 40

WOOD-FIRED PACKAGE BOILER MANUFACTURERS AND THEIR SYSTEM CHARACTERISTICS

Company and Location	Capacity	Boiler Efficiency	Fuel Moisture Limit
Industrial Boiler Co. Thomasville, GA	77 to 1,000 hp single boiler	60%	60%
Roy Burner Company San Francisco, CA	100 to 500 hp	80%	20%
Bethlehem Corporation Easton, PA	up to 30,000 lb./hr.	83%	25%
CNB Tri-Fuel Boiler Pittsburgh, PA	100 to 700 hp	80%	30%
Wellons Boilers Sherwood, OR	3,000 to 60,000lb./hr.	-	50%
Deltak Corporation Minneapolis, MN	15,000 to 100,000 lb./hr.	60 to 70%	55%

There are several other manufacturers of wood-fired package boilers not included in the table. Their systems are similar to one or more of the systems mentioned in Table 40.

Most wood-fired package boilers on the market today are automated or nearly automated. Many systems require only infrequent operator attention. Most package boilers will require some kind of collection devices to meet local air pollution codes.

It may be difficult to retrofit an existing steam plant with a wood-fired package boiler, due to space limitations. Wood systems require a larger area for wood handling and storage, and the combustion volumes are much greater than gas or oil, dictating a larger physical size for a given steam output.

Suspension and Cyclone Burners

The cyclone furnace for burning pulverized coal has enjoyed widespread use on utility boilers for many years. The fuel is very finely ground and blown into the furnace almost as a gas; as a result, the combustion process is very efficient and fly ash problems are easily dealt with.

Variations on the cyclone furnace concept have been developed for burning wood waste as well, but there are certain limitations which can hamper the feasibility for using these systems in many applications. The wood residue must be dry (less than 15% moisture content on a wet basis), and it must be hammermilled or hogged to fairly fine particles. In spite of these requirements, several companies have placed a large number of these units in industrial plants, largely in the forest products industry. They have been used to fire directly into boilers, rotary dryers for product drying, and for lumber dry kiln and veneer dryer applications. Company names, their systems, and characteristics are given in Table 41.

Fluidized Bed Combustors

Basically, a fluidized bed relies on a combustion chamber that has many holes drilled in the floor through which underfire air passes. This air blows through the "bed," which consists of small particles of sand, limestone, or other solid material. The bed is kept in suspension by the fans and is heated initially by an auxiliary fuel. When the bed reaches a temperature sufficiently high to ignite the fuel to be burned, the auxiliary fuel can be shut off and the solid fuel introduced. The turbulent mixing action

of the hot bed material helps ensure that the fuel is burned completely. Coal is generally used as fuel stock.

TABLE 41

WOOD CYCLONE BURNER MANUFACTURERS AND THEIR SYSTEM CHARACTERISTICS

Company and Location	System	Particle Size	Fuel Moisture Content	Unit Capacity
Moore-Canada Corp.	Energex	1/8"	up to 15%	6,15,27,45 & 60 million Btu/hr.
McConnell Industries Birmingham, AL	Market by Energex	1/8"	12% or less	6 to 40 million Btu/hr.
Guaranty Performance Independence, KA	ROEMMC	Small size	15% or less	10 to 30 million Btu/hr.
Coen Company Burlingame, CA .	DAZ	Depend on application	12% or less	5 to 100 million Btu/hr.
Peabody Gordon-Piatt Winfield, KA	Peabody	1/2"x1/8"	12% or less	9 to 36 million Btu/hr.

In wood burning systems, the fluidized bed combustors have shown promise as devices capable of burning wet fuels or fuels of irregular sizes and shapes. Several companies are actively marketing various fluidized bed systems, and many units have been operated successfully in the forest products industry. Possible drawbacks include relatively high first cost, maintenance requirements greater than a conventional boiler for the same capacity and high power requirements for the fans. Some systems are given in Table 42.

Pyrolysis Systems

Pyrolysis can be defined as burning without oxygen. The process involves the physical and chemical decomposition of solid organic matter caused by the action of heat in the absence of oxygen. Wood can be pyrolyzed to produce

TABLE 42

FLUIDIZED BED COMBUSTOR MANUFACTURERS AND THEIR SYSTEM CHARACTERISTICS

Company and Location	System	Bed Medium	Fuel Moisture Content	Unit Capacity
York-Shipley Co. York, PA	Fluid Flame	Sand	55%	3,800 to 60,000 lb/hr.
Johnston Boiler Co. Ferrysburg, MI	Johnston Fluid-Fire	Sand	-	5,000 to 50,000 lb/hr.
Combustion Power Co. Menlo Park, CA	not commercial	-	-	up to 100 million Btu/hr.

charcoal, and coal can be pyrolyzed to produce gas. Due to the intense heat in a pyrolytic reactor, complex organic compounds can be broken down into simpler chemical products. These products include liquids, gases, and a carbon char residue.

Various types of pyrolysis processes have been developed in recent years by different companies, but no systems are considered completely commercial today. Several of the systems that have shown promise for producing usable fuels from wood waste are listed as follows:

Tech-Air Corporation, Atlanta, Georgia

Enerco Corporation, Langhorne, Pennsylvania

Energy Resources Co., Inc., Cambridge, Massachusetts

Industrial Boiler Co., Thomasville, Georgia

Wood Gasifiers

In the truest sense, wood gasifiers are a subset of the wood pyrolysis units discussed in the previous section, a function of transforming solid biomass into a gaseous fuel. The wood gasification process is basically the same as the processes being developed to produce coal gas. Coal gasification has been used for years in the steel industry to produce coke with the resultant by-product of coke oven gas.

Many different equipment configurations in use for wood gasification are developed, but the "air" gasifiers generate the most interest today. These

gasifiers typically pass approximately 25% of theoretical combustion air through a glowing char bed, and several chemical reactions take place which result in a low heating value gas of 100 to 100 Btu/ft.^{3} More sophisticated are the "oxygen" gasifiers which pass pure oxygen through the char bed, which results in a gas heating value of 300 to 400 Btu/ft.^{3} Both of these gases, of course, have energy densities much lower than natural gas (1000 Btu/ft.^{3}), but the gas can still be a useful fuel for certain applications. The oxygen-blown units are much more expensive and, indeed, would be more dangerous to operate.

Considerable interest has been expressed recently in wood gasification as a retrofit technology for conventional gas/oil-fired boilers. A low Btu burner could be substituted for the existing burner and the unit could be fired with the wood gas. Some derating of the boiler would occur and the severity of this derating would depend on the particular design of the boiler.

Wood gasifiers involve undesirable constituents in the gas including certain tars and acids. They have a tendency to condense in pipes and burners if the gas is allowed to cool or if the gas is not "scrubbed" as it exists in the gasifier. The undesirable properties of the gas and the difficulties with grate slaggging and burnout have been the most formidable problems researchers have faced. Wood gasification systems available today cannot be considered fully "commercial," and many operational problems will have to be resolved.

Several concepts currently being developed for gasifiers include updraft gasifiers, downdraft gasifiers, cross-flow gasifiers, and fluidized bed gasifiers. Major systems and their characteristics are given in Table 43.

One of the most attractive aspects of wood gasifiers is the price. Gasification systems can be retrofited to an existing gas/oil burner for substantially less than the cost of a new wood boiler system. Industrial plant owners who have gas/oil boilers with significant useful life remaining will have an attractive alternative to an entirely new system.

TABLE 43

WOOD GASIFIER SYSTEMS AND THEIR CHARACTERISTICS

Company and Location	System	DESIGN	MEDIUM	CAPACITY
Halcyon Corporation East Andover, NH	Grossley	Updraft	Air or natural gas	10 million Btu/hr.
University of Calif. Davis, CA	Davis	Downdraft	Air	10 million Btu/hr.
Forest Fuels Co. Keene, NH	Forest Fuels	Cross-flow	Air	15 million Btu/hr.
Renault Corporation Valenciennes, France	Duvant	Downdraft	Air	-

Electric Power Generation

As the costs of oil and other fossil fuels continue to rise, many individuals and industrial firms are exploring the feasibility of producing electrical power by using biomass fuels. Hundreds of companies across the nation are meeting their heating and/or electricity needs by burning wood. Several wood-fired power plants are under active planning or consideration.[1/]

The federal government and some state govenments have provided legislative and tax incentives for establishing small power generating facilities with biomass as fuel material. These two incentive areas are briefly discussed.

The Public Utility Regulatory Policies Act of 1978 (PURPA) alleviates many of the legal constraints on the expanded use of electricity generated by small, disperse facilities. The Federal Energy Regulatory Commission (FERC) is in the process of issuing regulations to impliment PURPA. PURPA enables the FERC to exempt "qualifying industrial cogenerators" and "qualifying small power producers" from federal and state public utility regulations. A "qualifying small power producer," must meet the following three criteria:

1. It must produce electric energy solely from the use of biomass or other renewable fuels.
2. It must have a rated output capacity of less than 80 MW and greater than 10 KW.
3. The majority of ownership must be held by an entity other than an electric utility.

Both federal and state tax incentives are provided to individual and industrial small power producers. The Energy Tax Act of 1978 allows for a 10% business investment tax credit, in addition to the regular investment tax credit which is subtracted from a business income tax payment and is

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[1/] The California Department of Water Resources and GeoProducts Corporation have proposed a joint development for a 55-MW power plant with forest biomass as fuel in Lassen County, California. Dow Corning is designing a $30 million cogeneration project that would supply steam and electricity near Midland, Michigan, requiring an estimated 180,000 tons/year of wood. A 50-MW woodfired power plant in northern Vermont is under consideration. A study has been conducted to determine the feasibility of using forest biomass as fuel for generating electricity for a small-sized community (10,000) in Pennsylvania.

equal in amount to a certain percentage of capital equipment. The amount of credit given is the sum of the following percentages:

1. The regular percentage, which will be 10% until December 31, 1980, and 7% after January 1, 1981.
2. The energy percentage, which is a special credit of 10% for all property classed as "energy property"; this credit will apply between October 1, 1978, and December 31, 1982.

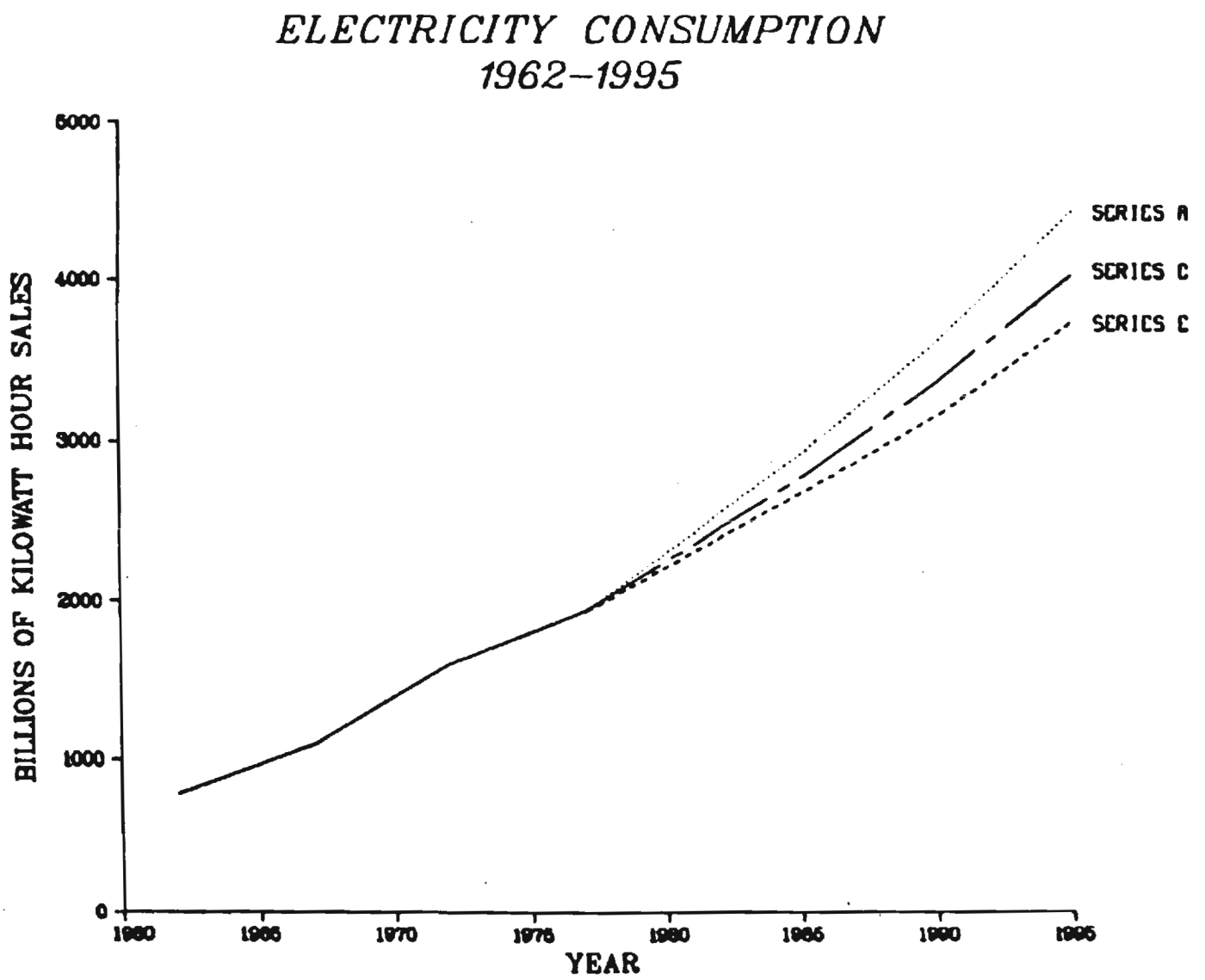
At the state level, small power producers may be eligible for a number of tax incentives. These incentives include income taxes, property tax exemptions, and sales tax exemptions, varying with individual states.

Recent legislation on both the federal and state levels has enhanced the ability of industrial and individual small power producers to obtain an order requiring public utilities to interconnect and wheel power. Interconnection allows a small individual power producer to transmit excess power to the public utility and/or receive backup service when needed. With interconnection, an individual power producer would avoid the need for expensive storage systems and would be assured a consistent supply of power for end uses that require an uninterrupted power supply. One may apply to the FER for an order requiring the public utility to interconnect if a private negotiation fails.

The U.S. electricity consumption increased from approximately 800 billions of kilowatt-hour sales in 1962, to about 2 trillions of kilowatt-hour sales in 1977, with an annual growth rate of 6.3%. The consumption was projected to reach 4 trillions of kilowatt-hour sales by 1995 (a medium-level projection), with an annual growth rate of 4%. The projection was made by the U.S. Department of Energy and is presented in Figure 6. Although the future growth rate is expected to be slower than in recent years, the projected increased volume is still enormous.

To meet the future electricity requirements and to reduce the reliance on fossil fuels, federal and state governments recently have provided legislative and tax incentives to small power producers using biomass resources for generating electricity, as mentioned previously. It appears that a small power plant fueled by forest biomass is the best choice for a wood energy demonstration center in Alabama. The generated electricity can be sold to a local municipality or to a public utility. Once the center is established, it is expected to be economically self-supporting.

Figure 6



Source: Energy Supply and Demand in the Midterm = 1985, 1990, and 1995, DOE/EIA-0102/52, U.S. Department of Energy, April 1979.

Technologies for small power generating plants with wood as fuel are readily available on a commercial basis. A feasibility study, which includes the selection of an appropriate electric power system, investment requirements for the system, wood biomass supplies, plant location, financial projections, environmental statements, and legal and marketing aspects of the local utility structure, should be initiated as Phase II of this study program. The completed feasibility study would become an effective tool in raising needed capital for the proposed power plant. It also can serve as a model for other communities to initiate a similar program.

The interest of small communities in generating their own electrical power has been increasing across the nation in recent years. A letter to the principal investigator of this project by the chairman of the Troy Industrial Development Board is accidental evidence of the need for the feasibility study mentioned. (See Appendix 3.)

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Appendix 1

PRIMARY WOODWORKING CONCERNS IN A 50-MILE RADIUS OF TROY, ALABAMA

ABBEVILLE
HENRY COUNTY

AAA WOOD PRODUCTS, INC.
P.O. Box 266
Abbeville 36310 585-2203 Emp. 76-100
B.J. Whiddon Pres. Yr. Est. 1969
Lumber, Crossties, Treated Lumber

ALABAMA FOREST PRODUCTS, INC.
Div. Of Great Northern Paper, Inc.
Hwy. 431, N. P.O. Box 9
Abbeville 36310 585-5229 Emp. 161-200
J.T. Woods General Mgr. Yr. Est. 1974
Pine Lumber, Veneer and Hardwood Plywood
Softwood Plywood

JONES-REYNOLDS FOREST PRODUCTS, INC.
P.O. Box 57
Abbeville 36310 585-5833 Emp. 21-30
R.J. Reynolds Partner Yr. Est. 1973
Pine Lumber, Hardwood Lumber, Crossties
Wood Chips

LINN LUMBER CO., INC.
Ozark Rd.
Abbeville 363310 585-3963 Emp. 21-30
W.D. Linn Owner
Lumber, Pallet Stock, Stakes

MONEY PULPWOOD CO.
101 Crimson Drive
Abbeville 36310 585-2261 Emp. 41-50
Lindy Money Owner Yr. Est. 1964
Pulpwood, Wood Chips, Logs

TILLIS LUMBER CO., INC.
P.O. Box 339
Abbeville 36310 585-3688 Emp. 6-10
M.L. Tillis Owner Yr. Est. 1973
Chips

ABBEVILLE WOOD PRODUCTS CO., INC.
P.O. Box 116
Abbeville 36310 585-2283 Emp. 41-50
H.J. Wallace Pres. Yr. Est. 1977
Treated Railroad Ties, Utility Poles,
Foundation Pilings

GREAT SOUTHERN WOOD PRESERVING, INC.
P.O. Box 458
Abbeville 36310 585-3461 Emp. 16-20
J.W. Rane Pres. Yr. Est. 1970
Pressure Treated Lumber, Creosote Treated
Lumber and Posts

ANDALUSIA
COVINGTON COUNTY

DAVIS HARDWOOD, INC.
P.O. Box 1395
Andalusia 36420 222-7214 Emp. 11-15
J. Davis Owner Yr. Est. 1974
Lumber, Crossties, Chips

DIXON LUMBER CO. INC.
P.O. Box 7
Andalusia 36420 222-4191 Emp. 76-100
S. Dixon Pres. Yr. Est. 1941
Lumber, Wood Chips

PHILLIPS LOGGING AND PULPWOOD CO.
1020 Stanley Ave.
Andalusia 36420 222-5740 Emp. 1-5
J. Phillips Owner Yr. Est. 1956
Pulpwood, Logs

POPE-JONES PULPWOOD
P.O. Drawer 878
Andalusia 36420 222-5015 Emp. 21-30
W.C. Jones, Jr. Owner Yr. Est. 1951
Pulpwood, Logging

THOMAS LOGGING CO.
Rt. 4 Box 367
Andalusia 36420 578-1405 Emp. 1-5
T. Thomas Owner Yr. Est. 1957
Logging

DIXON PLYWOOD
P.O. ox 369
Andalusia 36420 222-4163 Emp. 201-250
J. Vick General Mgr. Yr. Est. 1970
Plywood, Wood Chips

ANSLEY
PIKE COUNTY

UNION CAMP CORP.
Div. of Wayne N.J.
General Delivery
Ansley 36001 566-2995 Emp. 11-15
E.R. Fannin Foreman
Pulpwood

BRAGGS
LOWNDES COUNTY

CASEY LUMBER CO., INC.
Div. of Container Corp.
(mail Star Route, Minter, Al. 367761)
Braggs 36761 227-4981 Emp. 76-100
Doug Griffin Supt.
Lumber

CHAPMAN
BUTLER COUNTY

ROCKY CREEK LOGGING CO., INC.
P.O. Box 6895
Chapman 36015 376-225814 Emp. 51-75
Norman F. McGowin, Jr. Pres. Yr. Est. 1966
Logs, Pulpwood

UNION CAMP CORP.
Building Products Div.
P.O. Box 38
Chapman 36015 376-2241 Emp. 551-650
John H. Syme Resident Mgr. Yr. Est. 1966
Plywood, Lumber

CLAYTON
BARBOUR COUNTY

BRACEWELL AND ESTES WOOD COMPANY
P.O. Box 247
Clayton 36016 775-8865 Emp. 11-15
G.H. Bracewell Partner Yr. Est. 1964
Pulpwood

BUSH LUMBER CO., INC.
P.O. Box 415
Clayton 36016 775-8745 Emp. 11-15
N.C. Bush Owner Yr. Est. 1972
Lumber, Wood Chips, Crossties

DOZIER
CRENSHAW COUNTY

DOZIER LUMBER CO., INC.
P.O. Box 18500D CO.
Dozier 36028 496-3341 Emp. 21-30
H. Walden Partner Yr. Est. 1947
Lumber

ELBA
CAFFEE COUNTY

ELBA WOOD PRODUCTS, INC.
Rt. 2 P.O. Box 276
Elba 36323 897-6034 Emp. 21-30
C.J. Nickelson Owner
Lumber

GREAT SOUTHERN PAPER CO., INC.
Elba Woodyard
S. Reese Ave.
Elba 36323 897-2022 Emp. 11-15
H. Willis Dist. Forester
Logs, Pulpwood, Chips

WALKER PULPWOOD CO.
Rt. 2 Box 198-W
Elba 36323 897-6918 Emp. 1-5
W.J. Walker Owner
Pulpwood

WINDHAM LUMBER CO.
1107 Payne St. P.O. Box 424
Elba 36323 897-6503 Emp. 1-5
Jack Windham Jr. Partner Yr. Est. 1964
Lumber Dressing

EUFAULA
BARBOUR COUNTY

BRABHAM, W.M. LUMBER CO.
Boundry St.
Eufaula 36027 687-2468 Emp. 16-20
W.M. Brabham Owner
Pine Lumber

COWIKEE LUMBER CO.
Brick Yard Rd. P.O. Box 42
Eufaula 36027 687-2300 Emp. 21-30
F. Petry Partner Yr. Est. 1951
Hardwood Lumber

DIXON LUMBER CO., INC.
W. Washington St. P.O. Box 619
Eufaula 36027 687-3546 Emp. 101-150
R.M. Dixon Pres. Yr. Est. 1928
Lumber, Wood Chips

EUFAULA PULPWOOD CO., INC.
Montgomery Hwy. P.O. Box 78
Eufaula 36027 687-2784 Emp. 11-15
T.B. Jones Pres.
Pulpwood, Logging

GARRISON BROTHERS LUMBER CO., INC.
Brick Yard Rd., P.O. Box 329
Eufaula 36027 687-2261 Emp. 41-50
J.R. Garrison Partner Yr. Est. 1932
Lumber

UPSHAW PULPWOOD CO.
P.O. Box 78
Eufaula 36027 687-2784 Emp. 1-5
W. Upshaw Owner
Pulpwood

BARGANIER PULPWOOD AND LOGGING CO.
P.O. Box 353
Fort Deposit 36023 227-8786 Emp. 1-5
Tommy Barganier Owner
Pulpwood, Logs

BUCK TIMBER CO.
Rt. 1 Box 215
Fort Deposit 36023 227-4316 Emp. 1-5
P.L. Buxk Owner Yr. Est. 1976
Pulpwood, Logs

FORT DEPOSIT LUMBER CO.
P.O. Drawwer T
Fort Deposit 36023 227-4344 Emp. 16-20
B.L. Dabvis Pres. Yr. Est. 1976
Lumber, Crossties

GEORGIANA
BUTLER COUNTY

CASEY TIMBER CO.
Rt. 1
Georgiana 36033 376-9040 Emp. 6-10
Thomas J. Casey Owner Yr. Est. 1968
Lumber, Crossties

GOODWIN LOGGING CO.
Rt. 1 Box 235
Georgiana 36033 376-9361 Emp. 1-5
Alvin Goodwin Owner
Logging

LOWER PULPWOOD, INC.
Rt. 2
Georgiana 36033 376-2514 Emp. 6-10
L.J. Lower Owner
Pulpwood

SIRMON, JOHN D., PULPWOOD CO.
Rt. 1 Box 166
Georgiana 36033 376-9647 Emp. 1-5
J.D. Sirmon Owner
Pulpwood

WATSON POLE AND PILING CO., INC.
Rt. 1
Georgiana 36033 376-9363 Emp. 21-30
J.H. Watson Partner
Logging, Poles and Pilings

GLENWOOD
CRENSHAW COUNTY

LESTER, J.P., SAWMILL, INC.
P.O. Box 155
Glenwood 36034 335-5736 Emp. 31-40
J.D. Lester Bd. Chmn. Yr. Est. 1966
Crossties, Hardwood Lumber, Pine Lumber
Pine Timbers

GOSHEN
PIKE COUNTY

FLOYD'S SAWMILL, INC.
Rt. 2
Goshen 36035 566-6234 Emp. 11-15
Ray Floyd Owner Yr. Est. 1950
Lumber, Crossties, Chips

NORMAN TIE AND LUMBER CO., INC.
300 Rear Greenville Ave., P.O. Box 97
Goshen 36035 484-3241 Emp. 11-15
J.T. Norman Pres. Yr. Est. 1954
Lumber

HEADLAND
HENRY COUNTY

MCDANIEL LOGGING CO.
527 Main St.
Headland 36345 693-3139 Emp. 11-15
N. McDaniel Owner
Pulpwood, Logs

HIGHLAND HOME
CRENSHAW COUNTY

HOLMAN, J.W., LUMBER CO., INC.
P.O. Box 67
Highland Home 36041 537-4301 Emp. 21-30
C.E. Holman Pres. Yr. Est. 1945
Lumber, Crossties

LAPINE
CRENSHAW COUNTY

HARRIS PULPWOOD CO.
Rt. 1 Box 341
Lapine 36045 537-9159 Emp. 1-5
Z.W. Harris Owner
Pulpwood

LOCKHART
COVINGTON COUNTY

HENSON POLE AND TIMBER PLANT, INC.
General Delivery
Lockhart 36455 858-3817 Emp. 11-15
W.G. Henson Owner
Pulpwood

LOCKHART LUMBER CO., INC.
P.O. Box 207
Lockhart 36455 858-3247 Emp. 76-100
C.M. Jackson Pres. Yr. Est. 1958
Lumber, Posts and Poles, Wood Preserving
Pine Chips

LOUISVILLE
BARBOUR COUNTY

BOUTWELL LUMBER CO., INC.
Hwy. 130
Louisville 36048 266-5967 Emp. 16-20
E. Boutwell Owner Yr. Est. 1949
Lumber, Chips, Crossties

SLAWSON LUMBER CO.
P.O. Box 97
Louisville 36048 266-5362 Emp. 21-30
G. Slawson Owner Yr. Est. 1974
Pine Lumber

MIDWAY
BULLOCK COUNTY

CALDWELL PULPWOOD CO.
Rt. 2 Box 174
Midway 36053 529-3201 Emp. 1-5
C. Caldwell Owner
Pulpwood

MONTGOMERY
MONTGOMERY COUNTY

BEAR LUMBER CO., INC.
39 E. Jefferson St. P.O. Box 2071
Montgomery 36101 834-29611 Emp. 31-40
J. Bear Sr. Pres.
Lumber, Millwork

BUCHANAN LUMBER CO., INC.
P.O. Box 4130
Montgomery 36101 263-6647 Emp. 101-150
R.W. Buchanan, Jr. Pres. Yr. Est. 1961
Hardwood Lumber

DANIEL LOGGING CO., INC.
2741 Pelzer Ave.
Montgomery 36109 262-5582 Emp. 6-10
R. Daniel Pres.
Logging

KOPPERS CO., INC.
Forest Products Div.
1415 Louisville St., P.O. Box 510
Montgomery 36101 834-5290 Emp. 101-150
J. Hamilton Regional Mgr. Yr. Est. 1925
Treated Poles, Treated Crossties
Treated Lumber

MARSHALL LUMBEER AND MILL CO.
3200 Day St. P.O. Box 906
Montgomery 36102 262-3816 Emp. 31-40
J.R. Marshall Partner
Millwork, Lumber

BROWDER VENEER CO., INC.
1401 N. MDonough St., P.O. Box 1291
Montgomery 36102 262-2896 Emp. 41-50
V.G. Browder Pres.
Box Grade Veneer

CAPITAL VENEER WORKS, INC.
Jackson Ferry Rd., P.O. Box 3145
Montgomery 36109 264-1401 Emp. 76-100
R.L. Adams Pres.
Veneer

UNION CAMP COPRORATION
P.O. Box 326
Montgomery, Alabama 36101
R.A. Moore Manager
205-265-8841

NEW BROCKTON
COFFEE COUNTY

CONTAINER CORP. OF AMERICA
Div. of Mobil Oil Corp.
P.O. Box 106
New Brockton 36351 894-6416 Emp. 1-5
J. Hall Plant Mgr. Yr. Est. 1974
Pulpwood

GRANT AND GRANT LOGGING AND LUMBER CO.
Rt. 1
New Brockton 36351 894-6155 Emp. 1-5
M. Grant Partner
Logs, Lumber

NEWVILLE
HENRY COUNTY

STRICKLAND LOGGING CONTRACTOR
Rt. 2
Newville 36353 795-6281 Emp. 1-5
B.H. Strickland Owner Yr. Est. 1958
Logging, Pulpwood

PETREY
CRENSHAW COUNTY

BROWDER VENEER CO., INC.
P.O. Box 23
Petrey 36062 537-4454 Emp. 21-30
H.E. Browder Partner Yr. Est. 1951
Box Grade Veneer, Plywood Core Stock

PIKE ROAD
MONTGOMERY COUNTY

HOWELL LOGGING CO.
Rt. 1 Box 232
Pike Road 36064 288-0465 Emp. 21-30
G.C. Howell Owner Yr. Est. 1959
Logging

RAMER
MONTGOMERY COUNTY

JOHNSON PULPWOOD CO., INC.
Rt. 1 Box 173-B
Ramer 36069 584-7795 Emp. 11-15
T.J. Johnson Owner Yr. Est. 1966
Pulpwood

RED LEVEL
COVINGTON COUNTY

BUSH PULPWOOD CO., INC.
Rt. 3 Box 73-A
Red Level 36474 222-5912 Emp. 6-10
H.B. Bush Owner
Pulpwood, Logs for Plywood Veneer,
Crossties

SLOCOMB
GENEVA COUNTY

CASEY BROTHERS LUMBER CO., INC.
Esto Hwy. P.O. Box 362
Slocomb 36375 886-2331 Emp. 11-15
E. Casey Partner
Lumber, Hardwood Lumber

TROY
PIKE COUNTY

GREEN LAND, INC.
P.O. Box 604
Troy 36081 566-5570 Emp. 21-3
Burt Green Pres.
Crossties, Lumber Pallets, Wood Chips

KING PULPWOOD CO., INC.
Banks Hwy.
Troy 36081 566-3497 Emp. 6-10
J.OO. King Pres. Yr. Est. 1969
Pulpwood

P AND F PULPWOOD, INC.
Rt. 3
Troy 36081 566-1873 Emp. 1-5
R. Peacock Pres. Yr. Est. 1973
Pulpwood

SORRELL W.J., LUMBER CO., INC.
Rt. 5 Box Saco
Troy 36081 566-4084 Emp. 51-75
J.B. Money Mgr.
Pulpwood, Lumber

RAY GIBSON SAWMILL
Rt. 5 P.O. Box 2
Troy 36081 566-1394 Emp. 21-30
Ray Gibson Owner Yr. Est. 1948
Crossties, Lumber

WILLIAMS PULPWOOD CO., INC.
Rt. 3
Troy 36081 584-7862 Emp. 21-30
H.R. Williams Owner Yr. Est. 1959
Pulpwood

TUSKEGEE
MACON COUNTY

PITTS PULPWOOD
Rt. 2 Box 354
Tuskegee 36083 727-2683 Emp. 1-5
C.B. Pitts, Jr. Owner
Pulpwood

UNION SPRINGS
BULLOCK COUNTY

BRASWELL WOOD CO., INC.
Rt. 3
Union Springs 36089 738-4899 Emp. 6-10
J. Braswell Owner
Pulpwood

DANIEL SAWMILL CO., INC.
Rt. 1
Union Springs 36089 738-3948 Emp. 6-10
H. Daniel Owner
Crossties

SORRELL PULPWOOD AND LUMBER CO., INC.
Rt. 3
Union Springs 36089 738-3200 Emp. 11-15
J.B. Money Owner Yr. Est. 1930
Pulpwood

SPRINGER LUMBER CO., INC.
Troy Hwy. P.O. Box 208
Union Springs 36089 738-2310 Emp. 11-15
Joe M. Varner Owner Yr. Est. 1931

UNION CAMP CORP
Div. of Wayne N.J.
Rt. 1
Union Springs 36089 474-3738 Emp. 31-40
D. McGrady Mgr.
Pulpwood

WALKER PULPWOOD CO., INC.
Rt. 1 P.O. Box 266
Union Springs 36089 738-2920 Emp. 6-10
P.J. Walker Owner Yr. Est. 1971
Pulpwood, Crossties, Logs

WING
COVINGTON COUNTY

CROSBY LOGGING
Rt. 1 Box 63
Wing 36483 867-6931 Emp. 1-5
Claude Crosby
Pulpwood, Logging

Appendix 2

SECONDARY WOODWORKING CONCERNS IN A
50-MILE RADIUS OF TROY, ALABAMA

ANDALUSIA
COVINGTON COUNTY

ANDALUSIA MANUFACTURING CO., INC.
Central St.
Andalusia 36420 222-1171 Emp. 11-11
R. Merrill Pres.
Sash Doors, MilLwork

PHILLIPS CABINET SHOP, INC.
430 Pugh St.
Andalusia 36420 222-1558 Emp. 1-5
J.R. Phillips Owner
Cabinets

ELBA
COFFEE COUNTY

ELBA PALLETS, INC.
Hwy. 84 P.O. Box 276
Elba 36323 897-6421 Emp. 21-30
L.J. Little, Jr. V-Pres. Yr. Est. 1974
Wooden Pallets

EUFAULA
BARBOUR COUNTY

GILBERT MANUFACTURING CO., INC.
P.O. Box 613
Eufaula 36027 687-5786 Emp. 101-150
George L. Gilbert Pres. Yr. Est. 1967
Kitchen Cabinet Components

HARDWOOD DIMENSION AND MOLDING CO., INC.
State Docks Rd. P.O. Box 313
Eufaula 36027 687-5786 Emp. 31-40
George L. Gilbert Pres. Yr. Est. 1965
Furniture and Cabinet Wooden Components,
Moulding

SHAPEX CORP.
P.O. BOX 201
Eufaula 36027 687-6512 Emp. 21-30
John Howard Pres. Yr. Est. 1978
Wooden Parts (furniture), Kitchen Cabinets

FORT DEPOSIT
LOWNDES COUNTY

LOWNDES MANUFACTURING CO., INC.
P.O. Box 336
Fort Deposit 36023 227-4290 Emp. 6-10
L. Conway Owner
Engineering Stakes, Hubs, Wooden
Wedges and Strips

GEORGIANA
BUTLER COUNTY

JOYNER'S WOOD PRODUCTS
P.O. BOX 301
Georgiana 36033 376-9414 Emp. 1-5
C.L. Joyner Owner
Wood Turkey Calls

HEADLAND
HENRY COUNTY

CUSTOM COMPONENTS, INC.
P.O. Box 295
Headland 36345 693-3337 Emp. 11-15
J. Knowles General Mgr. Yr. Est. 1974
Roof Trusses, Wall Panels

E AND W BUILDING MATERIAL CO., INC.
100 Railroad Ave. P.O. Box 126
Headland 36345 693-3306 Emp. 6-10
R.A. Weeks Pres. Yr. Est. 1947
Roof Trusses, Wall Components

REBWOOD, INC.
Industrial Park P.O. Box 127
Headland 36345 693-3369 Emp. 51-75
R.W. Egbert Pres. Yr. Est. 1968
Bedroom Furniture

SOUTHEASTERN CABINET SHOP, INC.
Cleveland
Headland 36345 693-3216 Emp. 11-15
C. Howard Mgr. Yr. Est. 1967
Wooden Cabinets and Counter Tops,
Millwork Products

MONTGOMERY
MONTGOMERY COUNTY

ALABAMA WOODWORK CO., INC.
1528 Royal Park
Montgomery 36110 265-8195 Emp. 1-5
C.A. Ward Owner
Kitchen Cabinets, Commercial Millwork

ALLEN AND SONS CABINET CO.
2816 W. Edgemont Ave. P.O. Box 11251
Montgomery 36111 281-0163 Emp. 1-5
John H. Allen Partner Yr. Est. 1969
Cabinets, Millwork

AMERICAN CABINET AND BUILDING SUPPLY, INC.
1025 Bell St.
Montgomery 36104 262-4041 Emp. 6-10
W. McMurtrey Pres.
Cabinets

B AND B CABINET AND MILLWORK CO., INC.
715 N. McDonough P.O. Box 1642
Montgomery 36102 265-1109 Emp. 1-5
J.L. Byrd Owner
Mouldings and Trimmings, Cabinets and Counters, Windows, Doors

BISHOP, JIM, CABINETS, INC.
P.O. Box 11242
Montgomery 36111 288-1381 Emp. 16-20
J.F. Bishop Pres.
Wooden Cabinets

BOJAC INDUSTRIES, INC.
526 Oliver St. P.O. Box 3036
Montgomery 36109 272-6801 Emp. 6-10
J. Mathews Pres.
Solid Core Flush Panel Doors

BURTON LOUVER MANUFACTURING CO., INC.
2260 Fairview Ave. P.O. Box 2721
Montgomery 36105 834-2310 Emp. 11-15
J.B. Austin Pres. Yr. Est. 1967
Exterior Blinds

COMMERCIAL MILLWORK, INC.
2065 Exchange St. P.O. Box 17062
Montgomery 36117 288-0682 Emp. 6-10
R.O. Cobb Owner
Cabinets, Millwork

JIMCO MANUFACTURING, INC.
325 S. Hopper St. P.O. Box 7005
Montgomery 36107 264-5032 Emp. 1-5
J.A. Hapowski Owner Yr. Est. 1960
Custom Hotel and Motel Fixtures,
Store Fixtures, Bank Fixtures,
Custom Woodworking

KIMBALL FURNITURE REPORODUCTIONS, INC.
Div. of Kimball International, Inc.
1919 Bell St. P.O. Box 4248
Montgomery 36104 264-6441 Emp. 151-200
G. Bulger Plant Mgr.
Victorian Furniture Reproduction

LITTLE CABINET CO., INC.
1101 Greystone Dr.
Montgomery 36109 263-4706 Emp. 16-20
R. Little Pres. Yr. Est. 1959
Wood Kitchen Cabinets, Door Units,
Molding, Millwork

MASTER CRAFTSMAN
1215 Bell St.
Montgomery 36104 262-6952 Emp. 1-5
M. Stonacher Mgr. Yr. Est. 1974
Cabinets, Display Cases, Bars

MCCLENDON FURNITURE CO., INC.
P.O. Box 1828
Montgomery 36103 265-3518 Emp. 101-150
K. Rogers Pres. Yr. Est. 1940
Victorian Furniture Reproductions

MERIT BILT CABINET SHOP, INC.
1911 S. Holt St.
Montgomery 36104 264-2574 Emp. 1-5
M. Broadway Mgr.
Cabinets

MONTGOMERY BUILDING MATERIALS
903 Bell St. P.O. Box 731
Montgomery 36102 262-4861 Emp. 1-5
Robert F. Henry Jr. Pres. Yr. Est. 1927
Cabinets

MONTGOMERY CABINET TRIM
P.O. Box 11004
Montgomery 36111 281-6627 Emp. 6-10
J. Hubbard Partner Yr. Est. 1974
Cabinets, House Trim

NATIONAL SCREEN DOOR MANUFACTURING
CO., INC.
Div. of McPhillips Manufacturing Co., Inc.
430 Air Base Blvd. P.O. Box 1887
Montgomery 36103 262-8302 Emp. 51-75
E. Jennings Plant Supt.
Screen Door Units, Wood Windows

QUALITY DOOR AND MILLWORK CO., INC.
2135 W. Fairview Ave.
Montgomery 36108 834-6071 Emp. 6-10
Mrs. M.C. King Partner
Kitchen Cabinets, Doors, Trim

SOUTHERN LUMBER AND BUILDING SUPPLY,
INC.
1570 Jean St. P.O. Box 2802
Montgomery 36105 264-5346 Emp. 6-10
D. Brewer Pres.
Roof Trusses

SPEED SCREEN SERVICE, INC.
145 E. Fleming Rd.
Montgomery 36105 281-7237 Emp. 6-10
M. Bell Mgr.
Screens, Doors, Windows

STULL OF MONTGOMERY
1938 Miles St.
Montgomery 36104 2650-686 Emp. 1-5
G. Stull Owner Yr. Est. 1972
Victorian Beds, Dressers, Chests,
Custom Built Furniture

UNIVERSAL/NOLIN, INC.
Walk-In Cooler Plant
1400 Lloyd St. P.O. Box 1990
Montgomery 36103 263-4454 Emp.151-200
F.J. Frey V-Pres of Mfg. Yr. Est. 1960
Walk-In Coolers (storage rooms),
Shelving and Check-Out Counters

TUCKER MANUFACTURING CO., INC.
2400 Rice St. P.O. Box 681
Montgomery 36101 262-3509 Emp. 31-40
E.M. Tucker, Jr. Owner
Tent Poles, Tent Pins, Furniture
Dimension Parts, Cabinet Dimension
Parts

SLOCOMB
GENEVA COUNTY

R AND J CABINET SHOP
P.O. Box 576
Slocomb 36375 886-2521 Emp. 1-5
J. Carpenter Owner
Kitchen Cabinets, Vanities

SOCIETY HILL
MACON COUNTY

FOREST GARDENS, INC.
Rt. 2 Box 199, Opelika, Al 36801
Society Hill 36801 745-5481 Emp. 11-15
M. Sistrunk Pres. Yr. Est. 1975
Pine Bark Nuggets and Mulch

TROY
PIKE COUNTY

CONNOR-FLOYD MILLWORKS, INC.
P.O. Box 126
Troy 36081 566-4264 Emp. 6-10
G.W. Connor Pres. Yr. Est. 1964
Custom Cabinets, Window Frames, Door Frames, Crown Mouldings

HENDERSON, BLACK AND GREENE, INC.
110 Pike St.
Troy 36081 566-4133 Emp. 101-150
S.K. Hendricks Pres. Yr. Est. 1926
Columns, Wood Turnings, Wood Entrance Frames, Carved Panel Doors

QUALITY MILLWORKS, INC.
P.O. Box 168
Troy 36081 566-5500 Emp. 11-15
J.W. Law Pres. Yr. Est. 1971
Millwork

SUPERIOR MOULDING CO., INC.
910 Brundidge Blvd. P.O. Box 409
Troy 36081 566-0164 Emp. 76-100
H. Brown Partner Yr. Est. 1948
Wood Furniture Parts, Prefinished Wooden Cabinets, Doors and Drawers, Chopping Block Tables

WHALEY LUMBER AND CONSTRUCTION CO., INC.
225 Madison Ave.
Troy 36081 566-4630 Emp. 51-75
A. Whaley Pres.
Ready-Mix Concrete, Cabinets

APPENDIX 3

Letter from
Mr. Curren A. Farmer, Chairman
Troy Industrial Development Board

PIKE COUNTY MUSEUM ASSOCIATION

INCORPORATED 1969
TROY, ALABAMA 36081

30 October 1979

Tze I. Chiang
Principal Research Scientist
Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia
30332

Dear Mr. Chiang:

Your letter pertaining to wood as a heating fuel, addressed to the Retired Senior Volunteer Program, has been turned over to me to answer, because the RSVP office is in our museum.

I am glad to know that you are planning a demonstration center at Troy and will be glad to assist you in any way that I can. As chairman of the Troy Industrial Development Board, I have been trying to interest our city commissioners in generating their own electrical power from wood. We are living here in the woods and have a tremendous amount of wastage in the forests from logging and pulp wooding. It needs to be determined whether it is economically feasible to recover this source of energy.

Sincerely yours,

Curren A. Farmer

Curren A. Farmer
Route 6
Troy, Alabama 36081